Decentralizing Centralized Control

Reorienting a Fundamental Tenet for Resilient Air Operations

A Monograph

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Abstract

DECENTRALIZING CENTRALIZED CONTROL: REORIENTING A FUNDAMENTAL TENET FOR RESILIENT AIR OPERATIONS by Major Mark E. Blomme, USAF, 108 pages.

Communications technology has enabled the U.S. military to move data rapidly around the globe and provide commanders with the ability to monitor and maintain nearly constant communication with subordinates. However, this capability has the potential to tempt them to over-centralize control of operations, which can in turn erode the trust, initiative, and creativity of tactical-level decision makers. Each service's doctrine recognizes this potential, yet the Air Force alone insists on a tenet of "centralized control." In a complex environment where adaptive adversaries will adopt asymmetric methods to circumvent U.S. strengths, communication nodes and C2 systems may become critical vulnerabilities. The Air Force must recognize the need to embrace a degree of decentralized control and resource aircrews with the ability to directly gather information needed to make decisions. MASINT may inspire opportunities to field advanced sensors on combat aircraft, but more importantly, these new tactical sensors must be integrated into the broader ISR system and become so common that future Airman no longer refer to the implementation of such sensors as "Non-Traditional" ISR. These sensors could enable tactical-level decision makers to exploit the distributed nature of air operations and work towards the strategic ends of a centralized command, in an environment where adversaries will likely attempt to degrade U.S. information superiority.

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ABBREVIATIONS

3D	Three Dimensional
ACC	Air Combat Command
ACSC	Air Command and Staff College
AFDD	Air Force Doctrine Document
AFIT	Air Force Institute of Technology
AFMA	Air Force Manpower Agency
AFSC	Air Force Specialty Code
AGI	Advanced Geospatial Intelligence
AOC	Air and Space Operations Center
ASAT	Anti-Satellite
ATO	Air Tasking Order
AWACS	Airborne Warning and Control System
BDA	Battle Damage Assessment
C2	Command and Control
C3	Command, Control, and Communications
C3I	Command, Control, Communications, and Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CAOS	Combat Air Operations System
CAS	Close Air Support
CBU	Cluster Bomb Unit
CCD	Coherent Change Detection, or Camouflage, Concealment, and Deception
CFLCC	Coalition Forces Land Component Commander
CGSC	Command and General Staff College
CIA	Central Intelligence Agency
CNA	Computer Network Attack
CNN	Cable News Network

DHS	Department of Homeland Security
F2T2EA	Find, Fix, Track, Target, Engage, Assess
FAC	Forward Air Controller
FBIS	Foreign Broadcast Information Service
FCC	Functional Component Commander
FM	Field Manual
GBU-39	Guided Bomb Unit - 39 (Small Diameter Bomb - SDB)
GPS	Global Positioning Satellite
GWOT	Global War on Terrorism
HOF	Height of Function
HSI	Hyper-Spectral Imaging
IDE	Intermediate Developmental Education
I-SAR	Inverse Synthetic Aperture Radar
IO	Information Operations
IR	Infrared
IRINT	Infrared Intelligence
ISR	Intelligence, Surveillance, and Reconnaissance
JDAM	Joint Direct Attack Munition
JFACC	Joint Force Air Component Commander
JFC	Joint Force Commander
JP	Joint Publication
JTIDS	Joint Tactical Information Distribution System
LANTIRN	Low Altitude Navigation & Targeting Infrared for Night
LD/HD	Low Density / High Demand
LGB	Laser Guided Bomb
MACV	Military Assistance Command Vietnam
MANTIS	Multispectral Adaptive Networked Tactical Imaging System

MASINT	Measurement and Signature Intelligence
MILDEC	Military Deception
MSI	Multi-Spectral Imaging
MTU	Michigan Technological University
MWS	Major Weapon System
NASA	National Aeronautics and Space Administration
NTISR	Non-Traditional ISR
ºC	degrees Celsius
ºF	degrees Fahrenheit
OIF	Operation Iraqi Freedom
OODA	Observe, Orient, Decide, Act
OT&E	Operational Test and Evaluation
RADAR	Radio Detection and Ranging
ROE	Rules of Engagement
ROVER	Remote Operated Video Enhanced Receiver
RPD	Recognition-Primed Decision-Making
SAC	Strategic Air Command
SACEUR	Supreme Allied Commander Europe
SAASS	School of Advanced Air & Space Studies
SAMS	School of Advanced Military Studies
SAR	Synthetic Aperture Radar
SDB	Small Diameter Bomb (GBU-39)
TEG	Test and Evaluation Group
TST	Time Sensitive Target
UAV	Unmanned Aerial Vehicle
USAF	United States Air Force
USAFWS	United States Air Force Weapons School

> Never tell people how to do things, tell them what to do and they will surprise you with their ingenuity.
>
> – General George S. Patton Jr.

Introduction

The United States military is becoming accustomed to, and even dependent on, the free flow of information to and from the battlefield. The U.S. entered the twenty-first century as the world's sole super-power, and it maintains a military force capable of defeating any other fielded force head on – in large part due to its ability to exploit the information domain. The problem is that everyone knows this, and cunning adversaries will seek ways to avoid American military strengths by targeting critical vulnerabilities and exhausting its resources. Future threats are likely to seek ways to shock the U.S. military with asymmetric attacks that target U.S. information nodes to prevent communication with control elements, increase military deception (MILDEC) operations, and seek other ways to frustrate the American military's decision-making process.

In addition to pursuing methods to secure critical nodes, the U.S. must examine whether current doctrine is adequate to cope with the challenges future threats could pose to the ability to "command" and "control" forces. The U.S. should also consider whether to continue emphasizing the acquisition of national and theater assets that must "push" information to the warfighter, or to consider a shift in strategy that directly equips warfighters with advanced sensor technologies. This could increase the speed and reliability of receiving actionable intelligence as well as empowering lower levels of command to make decisions and take initiative when necessary. Such a strategy would decrease dependence on critical information-gathering nodes and provide a level of resiliency in an increasingly complex environment.

Technology shapes the world in new and exciting ways, overcoming physical barriers and bringing formerly disparate people closer together. The industrial revolution brought mass production and transportation efficiencies that allowed the movement of people and material on a scale previously unimaginable. The information age is similarly shrinking the world through

widespread communication technology that enables information to be shared at the speed of light. The result is increased interconnectivity and interdependence that is often referred to as Globalization.[1] The relationships that evolve from globalization create both significant opportunities and challenges, and they will no doubt increase the complexity of operating in the emerging environment.

Individuals able to connect to the internet have unprecedented access to information. Web-based applications like Google Earth allow free access to digitized geospatial information that once took nations with armies of specialists to consolidate and synthesize. Power is shifting from the few who "controlled" material resources to many individuals and organizations that can "command" informational and conceptual resources. The world is becoming more complex and communication technology is allowing faster cycles of change and adaptation.

The Department of Defense must look for ways to remain nimble in an increasingly complex environment or risk being caught unable to respond to challenges posed by asymmetric threats. Advances in communications are double-edged swords: they enable commanders to maintain higher awareness, but also tempt them to exercise tighter control, creating a potential vulnerability that astute adversaries may exploit. The U.S. military must ensure doctrine clearly and consistently defines the philosophy of "control" it believes appropriate for maintaining flexibility in the emerging environment, and must carefully weigh cost effectiveness against resiliency when deciding acquisition strategies to implement information enabling technologies, such as advanced sensor systems.

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[1] Thomas L. Friedman discusses the impact of globalization in two books. The *Lexus and the Olive Tree* was published in 1999 at a time when Friedman believes globalization was beginning to accelerate rapidly. *The World is Flat* was published in 2005 and it extends the arguments in the first book. Thomas L. Friedman, *The Lexus and the Olive Tree* (New York: Farrar, Straus, Giroux, 1999). Thomas L. Friedman, *The World Is Flat: A Brief History of the Twenty-First Century* (New York: Farrar, Straus and Giroux, 2005).

As part of the research conducted for this monograph, a survey was distributed to over 350 mid-career Air Force officers to obtain the perceived desirability of incorporating advanced sensor capabilities on tactical airborne platforms. Additionally, several questions attempted to elicit the respondents' perceptions on centralized verses decentralized decision-making. The complete survey, demographic data, and results are included in the appendix section, while applicable results are included in footnotes throughout the paper. However, it is clear from the survey results that mid-career officers believe that aircrew prefer to make targeting decisions based upon information from on-board verses off-board sensors, and that centralized decision-making is not preferred, even if technologically feasible. Furthermore, it highlighted that new sensor capabilities on tactical air-to-ground platforms will be needed to cope with future adversarial challenges, and that these sensors must be better integrated into the intelligence collection process.

The United States military has long recognized the benefit of maintaining information superiority as well as the decision-making advantages it affords. For several decades, the U.S. military has sought ways to quickly gather information and fuse it together so key decision-makers can make more timely and informed decisions. This type of approach can result in higher-level echelons being tempted to direct the tactical actions of warfighters on the front line. This possibility has led to numerous doctrinal warnings, from each of the services, about the danger of micromanaging and the need for decentralized execution – but the Air Force alone sustains a doctrinal call for "centralized control."

The central tenet of air and space power, "centralized control and decentralized execution," served the Air Force well in a less complex era where efficient use of limited resources was necessary, and there was less impetus to reorient efforts within the Air Tasking Order (ATO) cycle. However, "in very complex and quickly changing situations the most reasonable strategy is to plan only in rough outline and to delegate as many decisions as possible

to subordinates."[2] This seems to stand in contrast to the Air Force's central tenet – calling for centralized control.

Increased emphasis on Time Sensitive Targeting (TST) is the result of accepting that often, only rough plans can be made in advance.[3] It is one indicator of attempts to cope with the increasingly complex and adaptive nature of today's warfare, but the Air Force must doctrinally accept the need to delegate decisions as much as possible, look for ways to resource subordinates with the experience and information to make those decisions, and enable decentralized control as much as possible.

Time Sensitive Targeting authority and the information needed for making decisions have been trending towards centralization at the Air and Space Operations Center (AOC) level or above.[4] Tactical datalinks like the Joint Tactical Information Distribution System (JTIDS) have increased communal situational awareness by distributing information and increasing the real-time adaptive problem solving capabilities of aircrew. Nevertheless, the information sources that feed these datalinks are often funneled through a few centralized nodes like the AOC and airborne command-and-control (C2) platforms for distribution. Sometimes the information is automatically distributed to the warfighter using machine-to-machine communication methods, but too often, important information is distributed in a manner much more familiar to the game of

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[2] Dietrich Dörner, *The Logic of Failure: Why Things Go Wrong and What We Can Do to Make Them Right* (New York: Metropolitan Books, 1996), 161.

[3] Time Sensitive Target – "A joint force commander designated target requiring immediate response because it is a highly lucrative, fleeting target of opportunity or it poses (or will soon pose) a danger to friendly forces." U.S. Department of Defense, *Joint Targeting*, Joint Pub 3-60 (Washington, D.C.: Joint Chiefs of Staff, 2007). Ninety-three percent of mid-level Air Force officers believe that TST types of missions are a growing trend in air operations. Reference survey question #10. The results are graphically depicted in Appendix A, and the actual survey is depicted in Appendix B.

[4] In a joint operation, the AOC (Air and Space Operations Center) becomes a JAOC (Joint Air and Space Operations Center) and during a multinational operation, it becomes a CAOC (Combined Air and Space Operations Center. Since few operations are done unilaterally, "CAOC" has become the most common implementation. The Air and Space Operations Center is often referred to simply as the Air Operations Center.

"telephone" played on school grounds.[5] With each relay and transmission, the information can become increasingly distorted. By the time the information reaches the target audience, it may no longer be intelligible, and furthermore, the layers of relay can hinder timely attempts to receive clarification.[6]

Without taking the human out of the loop, technology can be used to help overcome human limitations and reduce the friction of human errors in war. It can speed the accurate flow of information and empower warfighters with the ability to collect, analyze, and process information on scales previously thought impossible. The cost and size of advanced sensors developed in the past may have dictated that fielding decisions should be restricted to large traditional ISR platforms, but today many of those limitations may no longer exist. Imagination

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[5] The game of telephone is often used on school grounds to teach children about the inaccuracy of rumors and the effect of cumulative errors. Players are asked to whisper a phrase given to them by the previous person to the next person in sequence until the last person receives the message. The final message often has little resemblance to the original. For example, stage magician Mac King is thought to have organized the largest known game of "telephone" in Vegas show in January 2004. The initial message was "Mac King is a comedy magic genius." After 614 participants, the final message had become "Macaroni cantaloupe knows the future." The game is also sometimes referred to as "Chinese Whispers." Wikipedia contributors, "Chinese Whispers," Wikipedia: The Free Encyclopedia, http://en.wikipedia.org/wiki/Chinese_whispers (accessed January 15, 2008).

[6] In a live-fly exercise in 2002, the author received airborne re-tasking against a time sensitive target. The tasking received was to simulate dropping 300 CBU-103s with 3 foot spacing and 900 foot Height of Function (HOF) on a set of coordinates. This tasking presented several questions in the author's mind. First, at that time the F-15E was not capable of carrying CBU-103s. Second, the aircrew had been tasked before takeoff to simulate carrying CBU-87s, an earlier, less precise version of the CBU-103. Third, the simulated ordinance on the aircraft was 3 CBU-87s, not 300. Fourth, weapon HOFs have to be set before takeoff; a 1200 foot HOF had been chosen and the setting is not adjustable in-flight. Did the AOC really want 3 weapons dropped with a 300 foot spacing? Was a 1200 foot HOF good enough? Was dropping CBU-87s through weather acceptable? How good were the coordinates? Were there any collateral damage concerns? Clarification on a few of these questions was sought over the radio while proceeding to the target area, but since the request had to be relayed back to the AOC and there were multiple TST activities occurring at the same time, a reply was never received. The crew discovered some vehicles parked within a few hundred feet of the coordinates, but considering the other inconsistencies there was reason to question whether the coordinates had been passed in error. In the meantime, the simulated enemy seemed to be communicating more effectively and was able to target the aircraft with a mobile Surface-to-Air Missile (SAM) system in the target vicinity – at least the training mission became more exciting at this point. Did anyone know there was a SAM threat in the area? Many good lessons were learned in the debriefing that evening, but the biggest lesson relearned was that radio relays are slow and prone to human error, especially when the relay operators are not familiar with what might even be a rational message. Tactical datalinks (LINK 16) were available, but nobody seemed willing to use them to help control TST operations.

and a willingness to question the accepted norm may be the catalyst needed to reveal previous assumptions that are no longer valid.

Some aspects of technology developed for traditional Intelligence, Surveillance, and Reconnaissance (ISR) assets appear mature enough to pursue acquisition strategies that allows the ability of non-traditional assets performing ISR missions, Non-Traditional ISR (NTISR), to be extended in a deliberate manner – instead of the haphazard approach taken in the past.[7] Such an extension would enable air operations to employ distributed decision-making in a culture becoming dangerously acclimated to an environment of centralized command-and-control. A military accustomed to centralized control could prove less resilient to network attacks and degraded communication if warfighters are not accustomed to decision-making and are cutoff from the information needed to execute their missions. However, tactical decision-makers, armed with sensor technology to directly acquire information, would likely be able to maintain some ability to operate in a degraded communication environment, thus continuing to pursue a higher commander's objectives.

Remote sensing is one realm of sensor technology that may generate ideas for future combat aircraft sensors. The products resulting from its military application are known as Measurement and Signature Intelligence (MASINT); generically, it involves the employment of methods other than electro-optical imaging (IMINT) and signal collection (SIGINT) to derive technical intelligence.[8] MASINT sensors gather data about the geospatial environment that can reveal detailed information, sometimes referred to as Advanced Geospatial Intelligence (AGI), often through the analysis of emitted and reflected energy from electromagnetic and mechanical

[7] Non-Traditional ISR grew out of the idea of gathering intelligence from weapon targeting sensors, carried on many tactical aircraft platforms, when not being employed to deliver weapons.

[8] Remote Sensing, as the name implies, is the collection of information about an object or event from a standoff position. A variety of instruments can be used to collect emitted or reflected energy that reveal details about the subject being observed.

waves. Remote sensing methods have been applied to a variety of applications in the civilian realm and a few examples include assessing crop health, locating marijuana plants, and finding pieces of the Space Shuttle Columbia after the reentry breakup that scattered fragments across Texas, as shown in Figure 1.[9]

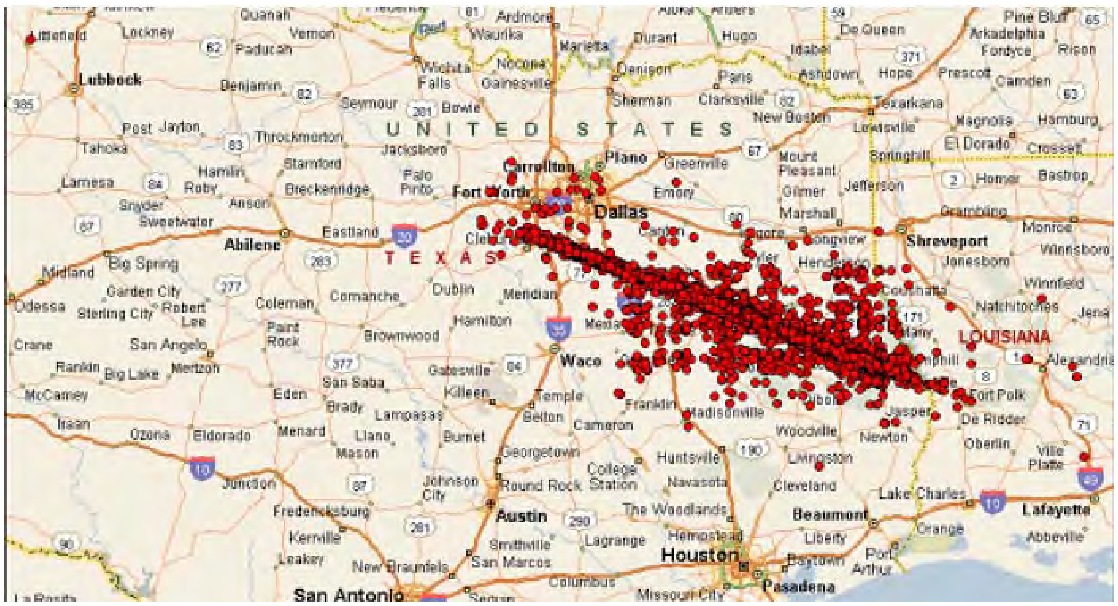

Figure 1. Space Shuttle Columbia Debris Field – STS-107[10]

The debris field resulting from the breakup of the Space Shuttle Columbia on February 1, 2003, covered a large area stretching from approximately Forth Worth, TX to Alexandria, LA. Hyperspectral sensors were incorporated with success to help cover the large area and look for characteristic spectral signatures of space shuttle materials.

Most airmen are familiar with Imagery Intelligence (IMINT) available from ISR platforms, but few have had the opportunity to see or train with products like Infrared Intelligence (IRINT), Synthetic Aperture Radar (SAR) images, or spectral images from strategic assets in the Air Force or other national intelligence communities. MASINT is involved with the development

[9] Nathan Setters, "MASINT for the Warfighter," in *OENG 535 Seminar* (Air Force Institute of Technology, Wright-Patterson AFB, OH: National Air and Space Intelligence Center, 2007).

[10] National Aeronautics and Space Administration, *STS-107 Columbia Reconstruction Report*, NSTS-60501 (Kennedy Space Center, FL: NASA, 2003), 3.

of each of these, but also exploits technical intelligence from sonar, seismic, acoustic, electromagnetic pulse, directed energy, nuclear, laser, and other emissions. It is hoped that the brief introduction to MASINT in this paper will inspire readers to imagine ways that MASINT and other technologies may be applied to enable decentralized control of distributed air operations so that better and more informed requirements can be developed for future acquisition programs. Increased awareness of technology should help facilitate the ability of warfighters to conduct more technology "pull," instead of depending on researchers to know what technology to "push" from the lab to the field.

This monograph explores both the joint and Air Force doctrinal positions relating to command, control, and command-and-control. It highlights the importance of using clear doctrinal language to increase joint understanding, and questions the appropriateness of the Air Force's dogmatic insistence on "centralized control" when what it really seems to care about is "centralized command." Centralized command enables a unified purpose, guiding framework, and usually some limited overarching control. While embracing centralized command, a high degree of decentralized control must be encouraged to foster initiative and resiliency among "distributed operations" – an evolution of Napoleon's "maneuver warfare," created by technology's ability to overcome many geographical and physical divides.

The British military and U.S. Army have adopted "mission command," a philosophy developed by the Prussian army and originally termed "Auftragstaktik"; however, it has been somewhat stifled within the U.S. Air Force by a tenet that calls for centralized control of air and space power. In this paper, alternatives to the Air Force's fundamental organizing principle are explored, the importance of "resourcing" warfighters with information is explained, and several approaches to provide warfighters with access to information needed for decision-making are discussed. While none of these methods is individually sufficient, they are complementary, and most effective when pursued in unison.

Awareness of the basic science and technical capabilities of remote sensing and MASINT is necessary in order to allow warfighters to understand the capabilities they can draw upon in planning and mission execution. Furthermore, it allows them to imagine the fielding of sensor capabilities that may offer great benefits for combat aircraft in the future. A cursory overview of MASINT is included in this paper to provide enough background for readers to imagine potential new applications. In the author's experience, few aircrew have been exposed to capabilities available through the application of sciences used to prepare MASINT products, and a survey, conducted as part of the research for this paper, indicated that a significant portion of those who believe they are familiar with MASINT do not expect to have access to it in combat.[11] Information will be a valuable resource for distributed operations, and resourcing airmen with MASINT inspired sensor technologies may allow aircrew to resource themselves with information, capitalize on data dissemination through peer-to-peer networking, enable distributed decision-making, and more importantly, increase resiliency in a future environment where adversaries may deny reliable communications and cripple attempts to maintain centralized control.

[11] Approximately 50% of the mid-career Air Force officers, who think they are familiar or very familiar with MASINT, believe that they will not have access to it in combat. Reference survey question #9. The results are graphically depicted in Appendix A, and the actual survey is depicted in Appendix B. Based upon the responses to four additional survey questions, there seems to be a perception that while aircrew have sufficient security clearances to access ISR products, not enough effort is made to make ISR products accessible. This could be the result of the intelligence community's propensity to operate on Top Secret level networks, even when working with Secret level products. This could also be an indication of the need to increase aircrew access to Top Secret level networks. Reference survey questions #34, #35, #36, and #37. The results are graphically depicted in Appendix A, and the actual survey is depicted in Appendix B.

Command, Control, and Command-and-Control

Alfred Korzybski, the father of General Semantics,[12] advocated that only the precise, scientific use of language could minimize the inherent confusion wrought by poor word choice.[13] The imprecise use of "command" and "control" in doctrine seems to support this claim. Precision can be achieved through a consistent use of words, but achieving an accurate understanding of the communicated message often requires a measure of definition and dialogue to placate inevitable cultural biases.[14] Words mold thoughts and thoughts can lead to actions; therefore, to avoid misperceptions and unintended actions, a concerted effort must be made to communicate clearly and consistently within doctrine.

The words "command" and "control" are not the same, and can be used independently in an intentional effort to communicate specific and separate concepts. However, sometimes they are used in a conjunctive manner to cast a broader net over a larger class of conceptual ideas, "command-and-control." In recent years, some communities have sought to expand the conjunctive context to include communications, computers, and the sphere of Intelligence, Surveillance, and Reconnaissance (ISR). The result is a growing ambiguity of terms and an assortment of acronyms: Command and Control (C2), Command, Control, and Communications

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[12] General Semantics emanated from the work of Alfred Korzybski in 1933. It is often referred to as a non-Aristotelian approach. While Aristotle believed that proper use of words could provide the true essence of something being defined, General Semantics holds that it is impossible for words to fully capture the objects true essence. There is a general "consciousness of abstracting" that must develop within a culture before it can effectively share experiences with words. A map/territory analogy is most often used to explain the three premises behind general semantics: 1. A map is not the territory. 2. A map does not represent all of a territory. 3. A map is self-reflexive in the sense that an 'ideal' map would include a map of the map, etc., indefinitely. Institute of General Semantics, "General Semantics," http://www.gestalt.org/semantic.htm (accessed December 20, 2008).

[13] Emory A. Griffin, *A First Look at Communication Theory* (Boston: McGraw-Hill, 1991), Chapter 2.

[14] Precision and Accuracy imply specific meanings within the scientific community. Precision refers to a level of consistency, while accuracy refers to the correctness or closeness to truth. A dart analogy is often used to convey the difference. A person who throws a tight cluster of darts is considered precise, even if the darts are not clustered near the target "bulls-eye." Accuracy on the other hand is the measure of how close the darts are to the target "bulls-eye."

(C3), Command, Control, Communications, and Intelligence (C3I), Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR), etc. Occasionally authors even appear to use “command” and “control” interchangeably – seemingly in an attempt to avoid monotony, but further clouding the actual meanings of the words.

In his seminal work, *Command in War*, military historian Martin Van Creveld explicitly chooses to use “command” as a simplifying catchall term for command, control, and communications (C3).[15] While his book is a clear indication that this technique can be used effectively, the simplifying approach can also cause confusion for a reader who fails to recognize this intentional choice. Attempting to compare the writings of authors without understanding the intent behind their word choice can cloud otherwise trivial issues. Definitions and explicit explanation by authors such as Van Creveld are probably the best way to clarify meaning; otherwise, a reader is forced to compare the larger context in which key words are used or make a potentially incorrect assumption. Collaborating authors face the additional challenge of trying to maintain a steady message stream within a single work or set of works. The broad set of military doctrine documents fall into this collaborative group. Not only is each doctrine document a collaborative effort, but the set of doctrine is the result of many different collaborative groups – often working years apart.

Doctrinal Definition Disparity

Military doctrine often uses the terms “command” and “control” independently, so it is important for military professionals to have a clear understanding of what is intended by each term. It is also imperative that military doctrine use the terms consistently; misinterpretation is inevitable if this does not occur.

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[15] Martin L. Van Creveld, *Command in War* (Cambridge, Mass.: Harvard University Press, 1985), 1.

Issues of misinterpretation are seldom highlighted within a single branch of the military because over time, its members come to a consensus on what is implied by the terms. New members have little or no pre-conceived frame of reference and, therefore, usually learn and accept the contextual meanings through cultural experience. However, communication with other services may be hampered when relying on these service-centric "implied" definitions, and the potential for confusion is only amplified when trying to communicate within a multi-agency or multi-national setting.

The growing interdependent nature of joint warfare should embolden military professionals to seek more consistency between service and joint doctrine. In doing so, it is likely that textual changes will be necessary in order to clearly communicate the intent of doctrine. Unfortunately, such doctrinal changes are often unabashedly opposed, sometimes based on reasonable rationale, other times because of sheer obstinance. The former leaves room for dialogue, debate, and an eventual solution; the latter merely erodes the value of doctrine itself by refusing to let it adapt.

"Centralized Control and Decentralized Execution" has become a hallmark of U.S. Air Force Doctrine. It is the first of seven tenets in the Air Force's top-level doctrine document, *Air Force Basic Doctrine* (AFDD 1). This tenet is referred to as "the fundamental organizing principle for air and space power."[16] Given the prominent status of this tenet within the Air Force, and the increasingly embedded nature of joint doctrine and operations, one would hope to find the same axiom reflected in joint publications. However, a review of Joint Pub 1, *Doctrine for the Armed Forces of the United States*, and Joint Pub 3-0, *Joint Operations*, reveals it is conspicuously absent. Only in Joint Pub 3-30, *Command and Control for Joint Air Operations*, is there an explicit acknowledgement of the Air Force tenet, and it is worth noting that the Air Force

[16] U.S. Air Force, *Air Force Basic Doctrine*, AFDD 1 (Maxwell Air Force Base, AL: Air Force Doctrine Center, 2003), ix.

was the lead agency responsible for this joint publication. "Decentralized Execution" is widely encouraged throughout both Air Force and joint doctrine, so the key issue seems to be a potential disagreement regarding "Centralized Control." This raises the questions of how much disparity actually exists, and whether this disparity has implications for joint warfighting.

To analyze whether there is a true divide in concepts between Air Force and joint doctrine, it is helpful to compare the definitions of "command" and "control." Both words appear to have specific military connotations in doctrine. However, joint doctrine routinely uses the word control, usually in reference to "command-and-control," without first adequately defining it. The *Department of Defense Dictionary of Military and Associated Terms,* Joint Pub 1-02, merely defines "control" as follows:

> Control [Joint]: Authority that may be *less than full command* exercised by a commander over part of the activities of subordinate or other organizations.[17] [Emphasis added]

Joint Pub 1-02 further defines "command" as follows:

> Command [Joint]: The *authority* that a commander in the armed forces lawfully exercises over subordinates *by virtue of rank or assignment*. Command includes the *authority* and *responsibility* for effectively using available resources and for planning the employment of, organizing, directing, coordinating, and *controlling* military forces for the accomplishment of assigned missions. It also includes responsibility for health, welfare, morale, and discipline of assigned personnel.[18] [Emphasis added]

Hence, the joint definition of "command" uses the word "controlling" within its definition while the definition of "control" implies some level of authority less than "command" without any additional clarification. This circular defining logic implants the seeds of confusion and misunderstanding.

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[17] U.S. Department of Defense, *Department of Defense Dictionary of Military and Associated Terms*, Joint Pub 1-02 (Washington, D.C.: Joint Chiefs of Staff, 2007), 120. It is likely that this definition was intended to apply to Operational Control (OPCON) and Tactical Control (TACON), but each of these is by definition a "command" authority and they would have been better labeled as such, i.e. OPCOM vs. OPCON.

[18] Ibid., 101.

The problem with imprecise definitions of "command" and "control" in multi-service and joint doctrine was highlighted well over a decade ago in a report prepared by Lt Col Gregory Roman, USAF. Fortunately, Air Force doctrine now attempts to provide clearer definitions of these two key words.[19] While accepting the previously stated joint doctrine definition for command, Air Force doctrine also provides a definition of control, which is consistently stated in both its basic doctrine, AFDD 1, and the *Command and Control* doctrine document, AFDD 2-8. This definition expounds upon the relationship between command and control.

> Control [Air Force]…the process by which commanders *plan, guide*, and *conduct* operations. The control process occurs before and during the operation. Control involves dynamic balances between commanders directing operations and allowing subordinates freedom of action.[20] [Emphasis added]

In this context, "control" balances the authority and responsibility of higher command with the flexibility of lower level echelons to decentralize execution of an assigned mission or task. This balance is done through a process of directing the planning, guiding, and conduct of operations, in a unified effort, toward a common purpose and desired end state. To reinforce this deduction, one can turn back to Joint Pub 1-02 for the joint definition of "command-and-control."

> Command-and-Control [Joint / Air Force]: The exercise of *authority* and *direction* by a properly designated commander over assigned and attached forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in *planning, directing, coordinating,* and controlling forces and operations in the accomplishment of the mission.[21] [Emphasis added]

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[19] Gregory Roman, "The Command or Control Dilemma: When Technology and Organizational Orientation Collide" (Air University, 1996).

[20] U.S. Air Force, *Command and Control*, AFDD 2-8 (Maxwell Air Force Base, AL: Air Force Doctrine Center, 2007), 5.

[21] U.S. Department of Defense, *Department of Defense Dictionary of Military and Associated Terms*, 101-102.

This joint definition successfully combines the concepts embodied by the Air Force doctrine definitions of "command" and "control" and is the same definition adopted by the Air Force in AFDD 1.

With a clearer idea of the doctrinal meanings of command, control, and command-and-control, it is easier to examine other statements within joint doctrine and relate their contextual meaning in relation to these three terms. The following three statements provide insightful understanding and demonstrate remarkable consistency.

1. JP 1: Unity of effort over complex operations is made possible through decentralized execution of centralized, overarching plans.[22]
2. JP 1: Commander's intent represents a unifying idea that allows decentralized execution within centralized, overarching guidance.[23]
3. JP 3-30: Unity of effort, centralized planning and direction, and decentralized execution are key considerations when organizing assigned forces.[24]

Careful review of each of these statements from joint doctrine reveals three recurring themes.

1. The concept of centralized command embodied by unity of effort and commander's intent.
2. The principle of decentralized execution.
3. The idea of some centralized control as indicated by remarks regarding centralized overarching planning, guidance, and direction.

Thus, even though joint doctrine at first seems to be conspicuously missing the Air Force's first tenet and fundamental organizing principle, "Centralized Control and Decentralized Execution," the concept may be at least somewhat embraced by joint doctrine, even if not stated explicitly.

[22] U.S. Department of Defense, *Doctrine for the Armed Forces of the United States*, Joint Pub 1 (Washington, D.C.: Joint Chiefs of Staff, 2007), IV-15.

[23] Ibid., IV-16.

[24] U.S. Department of Defense, *Command and Control for Joint Air Operations*, Joint Pub 3-30 (Washington, D.C.: Joint Chiefs of Staff, 2003), I-2.

The next questions are to what degree centralization should occur, and whether there is a better way to phrase the Air Force's first tenet.

Although a thorough review of joint doctrine has revealed a degree of conceptual consistency with Air Force doctrine, it is important to recognize again the confusion caused by the imprecise and varying use of doctrinal terms. To re-highlight the potential confusion, it is informative to look at definitions for "Centralized Control" from *Command and Control of Joint Air Operations* (JP 3-30) and *Air Force Basic Doctrine* (AFDD 1). It is interesting to note the differences while keeping in mind that the Air Force was also the lead agency for the joint doctrine document.

> JP 3-30: Centralized control is placing within one commander the *responsibility* and *authority* for planning, directing, and coordinating a military operation or group/category of operations.[25] [Emphasis added]

> AFDD 1: Centralized control…is the *planning, direction, prioritization, synchronization, integration, and deconfliction* of air and space capabilities to achieve the objectives of the joint force commander.[26] [Emphasis added]

Based upon the preceding discussions it should be clearer that the concept of "responsibility and authority" implies that what the joint air operations doctrine is referring to is more consistent with centralized command than centralized control. This inconsistency increases the propensity for misunderstanding and is most likely a deleterious result of joint doctrine's refusal to define "control" clearly and the Air Force's inability, as lead agent, to keep a consistent theme between the two documents.

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[25] Ibid., I-30.

[26] U.S. Air Force, *Air Force Basic Doctrine*, 28.

Span of Control

"Span of Control" is another related concept found in both joint and Air Force doctrine, but once again, there is a lack of consistency in the application of terms. The word "span" usually invokes a notion of breadth, and "span of control," as discussed in AFDD 2-8, is consistent with a breadth of control granted by a higher commander. However, Joint Pub 1's explanation of span of control seems clearly related to a "depth" of control retained by the Joint Force Commander (JFC) over forces. AFDD 1 tends to use "span of control" in a manner similar to joint doctrine, but cautions against multihatting the JFC as a Functional Component Commander (FCC).[27] Therefore, when joint doctrine uses "span of control" it seems to imply a level of delegation, but within Air Force doctrine, it may imply either a level of delegation or a breadth of control encompassing assets across the theater.

Joint doctrine suggests that a commander should weigh many factors in deciding the span of control appropriate for each operation and offers that the result of this consideration should be a choice between centralized or decentralized control. However, Air Force doctrine is adamant regarding the necessity of centralized control for air and space operations. A person is left wondering if there is something unique about air and space operations that suggests decentralized control would be inappropriate.

[27] U.S. Department of Defense, *Doctrine for the Armed Forces of the United States*, IV-19.

A favorable situation will never be exploited if commanders wait for orders. The highest commander and the youngest soldier must always be conscious of the fact that omission and inactivity are worse than resorting to the wrong expedient.

– Helmuth Karl Bernhard Graf von Moltke

Decentralizing Centralized Control

Joint doctrine seems to pose the choice between centralized or decentralized control in a typical "either/or" pattern of modern Western thought. This framing tends to ignore a "both/and" possibility. This black and white type of thinking is sometimes referred to as an Informal Fallacy of False Dilemma or an example of the "Law of the Excluded Middle."[28] The real value of thinking about a "span" of control is that there is a middle ground that can be tolerated. Some degree of order must be maintained, but too much control can lead to micromanagement – and there are ample warnings that accompany the Air Force's demands for centralized control.[29]

A choice between centralized and decentralized should not be necessary. Depth or "span" of control in the joint context is fundamentally about recognizing a spectrum of control verses choosing between two extremes. In Aristotelian philosophic fashion, one might reason that a virtuous commander is temperate in the level of control exercised, choosing a middle ground and avoiding the outcome of the extremes – micromanagement and chaos – depicted in Figure 2.

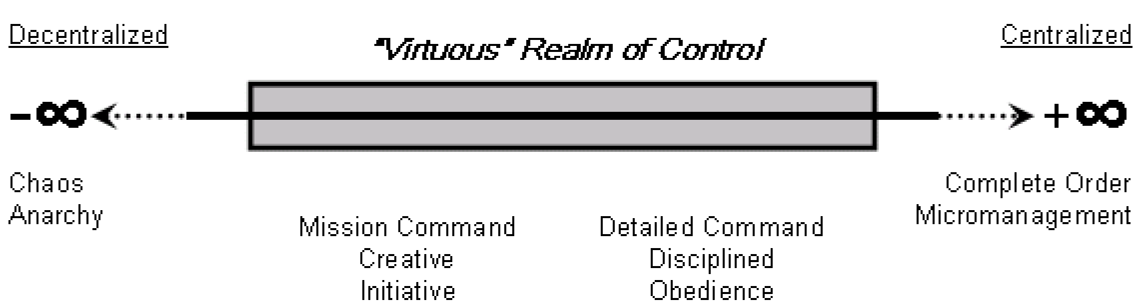

Figure 2. Depth of Control – An Aristotelian Perspective

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[28] Fallacy Files, "Black-or-White Fallacy," http://www.fallacyfiles.org/eitheror.html (accessed December 1, 2007).

[29] U.S. Air Force, *Air Force Basic Doctrine*, 28.

In his doctoral thesis from the Massachusetts Institute of Technology, Lt Col Michael Kometer explores the impact of the Information Age on the Air Force's tenet of "centralized control and decentralized execution" through a lens of systems theory. He explains that the level of control has varied in modern air campaigns to reflect the Clausewitzian extension of political objectives. His research notes that when airpower has been used in a limited manner to increase coercive diplomatic pressure, the level of oversight placed upon operations has increased, and increased oversight has driven tighter control of tactical operations out of fear over unwanted strategic escalation.[30] He contends that in a loosely coupled Combat Air Operations System (CAOS), the function of individual system components have very little direct impact on other components.[31] The components retain a great deal of independence and so little causality can be inferred. Attempting to predict the outcome of changes in a loosely coupled system is extremely difficult because of the complexity involved. In a tightly coupled system, interactions among various components can be fairly well known and hence predictable outcomes are easier to envision and forecast.[32] Wesley Salmon, who has explored the concept of causality, might describe Kometer's tightly coupled system as reflecting a high degree of mechanistic determinism while loosely coupled systems tend to be more mechanistically indeterminate.[33] However, the world is not static, hence neither is the state of a Combat Air Operations System. Circumstances

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[30] Michael W. Kometer, "Command in Air War : Centralized Vs. Decentralized Control of Combat Airpower" (Ph.D. Thesis, Massachusetts Institute of Technology, 2005), 99.

[31] Coupling is a term often used to describe the degree of interdependence among various items. Loosely Coupled – "an attribute of systems, referring to an approach to designing interfaces across modules to reduce the interdependencies across modules or components – in particular, reducing the risk that changes within one module will create unanticipated changes within other modules." John. Hagel III, "Loosely Coupled: A Term Worth Understanding," John Hagel and Associates, http://www.johnhagel.com/view20021009.shtml (accessed January 31, 2008).

[32] Kometer, 66.

[33] Wesley C. Salmon, *Causality and Explanation* (Oxford: Oxford Univ. Press, 1998), 37. Mechanistic Determinism – Events are completely determined and caused by previous events. Mechanistic Indeterminism – Events are not completely determined or caused by previous events and regardless of the amount of information obtained, it is still not possible to predict or explain any causality.

will inevitably drive changes in the system, and the degree of control exercised may similarly need to be redressed over time.

Span of control can vary from campaign to campaign, within a campaign, and even among tactical missions being conducted concurrently. A more centralized control approach may be appropriate for missions within relatively static environments that require little real time or detailed coordination among system components; they can be planned in advance.[34]

Strategic bombing of fixed targets as well as strategic surveillance and mobility missions lend themselves more tolerant to centralized control and political constraints. However, missions that necessitate dynamic interactions among friendly, or between friendly and enemy system components will need a more decentralized control philosophy.[35] The former are tightly coupled, while the later are more loosely coupled. Loose coupling increases flexibility but also increases the prevalence of Clausewitz's "fog and friction." Fog of war – the result of inevitable uncertainty.[36] Friction in war – the outcome of natural stresses that render otherwise easy tasks difficult.[37]

Macro decisions regarding the level and form of control are part of campaign design. They result from the operational art of framing ill-structured problems into a set of problems that are well structured and able to be handed to planners for them to solve. Analysis of doctrinally accepted command structures and philosophies as well as a realistic expectation of cultural

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[34] While survey results indicate that mid-career officers in the Air Force feel that decision-making in both Low Intensity and High Intensity is currently over-centralized, there appears to be a measure of recognition that in low intensity conflicts this may be more acceptable. For Low Intensity conflict, 56% of respondents believed it was over-centralized, with 12% disagreeing. For High Intensity conflict, 39% of respondents believed it was over-centralized, verses 21% who disagreed. It is interesting to note that nearly twice as many respondents were neutral for the High Intensity question. Reference survey questions #30 and #31. The results are graphically depicted in Appendix A, and the actual survey is depicted in Appendix B.

[35] Kometer, 244.

[36] Carl von Clausewitz, *On War*, ed. Michael Howard and Peter Paret (Princeton, N.J.: Princeton University Press, 1984), 101.

[37] Ibid., 121.

adaptability are considerations made in the campaign design process. Doctrinal presupposition of a single control philosophy may artificially limit the artistic freedom of campaign designers. Some aspects of operations will necessarily need to be planned, coordinated, synchronized, and deconflicted by higher-level planners, but the growing complexity of operations and the adaptive nature of the future operating environment suggest that execution decisions and details should be left unconstrained to the maximum extent possible.[38]

During the Cold War era of Strategic Air Command (SAC) dominance, centralized control may have been tolerable and even necessary. A loss of some flexibility was acceptable. It provided an increased assurance that rigid standards were followed with nuclear armed forces. However, there was a price to be paid when Air Combat Command (ACC) was created in the wake of the Soviet Union's collapse. Nuclear-certified crews indoctrinated in the rigid procedural culture of SAC provided commanders with peace of mind in the Cold War, but in the immediate post Cold War era, they were perceived to have a difficult time adjusting to an environment that valued initiative and flexibility. They had become accustomed to centralized control.

The notion of centralized control, if too greatly entrenched in doctrine and the minds of warfighters, can lead to tactical decisions being unnecessarily referred back to higher-level commands. The time required to coordinate these referrals slows the tempo of operations and decreases the effectiveness of military operations.[39] For a service that has long prided itself on speed and flexibility, this seems to be the wrong direction to proceed. Initiative is a valuable commodity in war and should be encouraged whenever possible. It is much harder to train people to take initiative than to constrain those who have developed it. With this in mind, it is likely that

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[38] William E. Young, "JFACC as Architect: Using Systemic Design to Create Options in a World of Wicked Problems" (Masters Thesis, Air University, 2006).

[39] David Potts, *The Big Issue: Command and Combat in the Information Age*, CCRP Publication Series (Washington, DC: CCRP Publication Series, 2003), 85.

the Air Force would be wiser to adopt a concept that promotes "Decentralized Control" while noting that some limited degree of centralized control is still necessary.

Centralized Command vs. Centralized Control

A decisive point in the formulation of the Air Force's tenet of centralized control was the experience in North Africa during World War II and the perceived ineffectiveness of providing ground forces with organic air assets that prevented efficient theater application of airpower. In his book, *Airpower's Gordian Knot*, Lt Col Stephen McNamara provided a comprehensive review of the development of airpower up through Operation Desert Storm and noted that the concept of centralized "control" of air power has become nonnegotiable to the Air Force. His assessment would seem to indicate that there is little room for the Air Force to maneuver from its tenet of centralized control and decentralized execution. However, further review of his work suggests that the central issue that has truly become nonnegotiable is the concept of centralized "command" of airpower, under an airman responsible for the theater air campaign – a Joint Force Air Component Commander (JFACC) who reports directly to the JFC.[40]

Functional component commanders, including the air component, have become a well-accepted foundation of joint operations since Operation Desert Storm. While the danger of an over-extended span of command/multihatting is still a legitimate concern expressed in Air Force doctrine, there appears to be no pending challenge to the Air Force's demand for a JFACC. As a result, there may be some room for negotiation on the Air Force's "nonnegotiable" demand for centralized control.[41] In fact, even after commenting that centralized control was nonnegotiable,

[40] Although the JFACC is commonly a USAF "Airman," doctrinally it does not have to be. However, it should be an airman (lower case) – familiar and trained in the operational level employment of air and space assets. If the Navy is providing the preponderance of air assets, it is easily conceivable that the JFACC could be a senior naval aviator.

[41] When asked about the desirability of centralizing decision-making, an overwhelming number of mid-level Air Force officers believe that decision-making should not be centralized – even if technologically feasible. For low intensity conflict, mid-level officers disagreed with a statement that

Lt Col McNamara concludes his book with a suggestion that the JFACC become less involved in the daily tactical control of air operations and focus more on orchestrating the theater air campaign.[42] Considering the role McNamara's ideas have played in educating today's generation of airpower strategists, his suggestion about curbing control is noteworthy and seems to confirm that centralized control may not be the best way to phrase what is truly nonnegotiable for airmen.

"Centralized Command" seems to be a tenable concept that more accurately reflects the Air Force's doctrinal concerns about losing the ability to achieve unity of effort in air operations and over-controlling the execution phase. Centralized command is so much in keeping with the intent of Air Force doctrine, that it is sometimes incorrectly cited as the Air Force tenet. In fact, an Air War College paper published in 2003 consistently misquotes Air Force doctrine seven times, including in its title "Centralized Command – Decentralized Execution: Implications of Operating in a Network Centric Warfare Environment."[43] The author's main points and conclusions are still valid, but he and his advisors apparently never recognized the mistake. The error, the fact that nobody seemed to catch it, and that it did not change the context of the paper all help suggest that centralized command may indeed already be an acceptable replacement for centralized control as a tenet of air power. Other authors have used "command" and "control" almost interchangeably. Lt Col Baltrusaitis often refers to "centralized command" and "centralized control" as tenets of airpower in his paper titled "Centralized Control with

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suggested decision-making should be centralized as much as technologically feasible by a ratio of approximately 3:1. For high intensity conflict, that ratio grew to 4:1 and the percentage of respondents that "strongly disagree" nearly doubled. Reference questions #32 and #33. The results are graphically depicted in Appendix A, and the actual survey is depicted in Appendix B. "Decision-making" was used instead of "control" to help prevent non-reflective thought and answers that might blindly agree with the AF tenet of centralized control.

[42] Stephen J. McNamara, *Air Power's Gordian Knot: Centralized Versus Organic Control* (Maxwell Air Force Base, Ala.: Air University Press, 1994), 151-154.

[43] Richard M. Gomez, "Centralized Command -- Decentralized Execution: Implications of Operating in a Network Centric Warfare Environment" (Air University, 2003), 2.

Decentralized Execution: Never Divide the Fleet?"[44] However, "centralized command" is not explicitly stated as a tenet of airpower.[45] Baltrusaitis' paper is very complementary to Kometer's thesis but more directly questions the dogmatic manner in which the Air Force has held on to centralized control and decentralized execution. While Baltrusaitis sometimes appears to interchange centralized command and centralized control as a doctrinal tenet of airpower, he also recognizes that they are not the same.[46] In full context, there is no confusion about his position, but taken out of context his references to "centralized command," as a current tenet of airpower, may add to confusion about the differences between "centralized command" and "centralized control."

It is interesting to compare current Air Force doctrine to what it might look like with subtle changes.

> <u>Current Doctrine</u>: Centralized control of air and space power should be accomplished by an airman at the air component commander level who maintains a broad theater perspective in prioritizing the use of limited air and space assets to attain established objectives in any contingency across the range of operations. Centralized control maximizes the flexibility and effectiveness of air and space power; however, it must not become a recipe for micromanagement, stifling the initiative subordinates need to deal with combat's inevitable uncertainties.[47]
>
> <u>Potential Doctrine</u>: *Command* of air and space power should be *maintained* by an airman at the air component commander level who maintains a broad theater perspective in prioritizing the use of limited air and space assets to attain *centrally* established objectives in any contingency across the range of operations. *De*centralized control maximizes the flexibility and effectiveness of air and space power *when guided by commander's intent and purpose*. (Emphasized words highlight changes from current doctrine)

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[44] Daniel F. Baltrusaitis, *Centralized Control with Decentralized Execution: Never Divide the Fleet?* (Maxwell Air Force Base, AL: Air University, Air War College, 2004), 56.

[45] A new version of AFDD 1 was published shortly before Baltrusaitis paper was published. While keeping the same seven Air Force tenets, the 13 Nov 2003 version removed the only explicit reference to "centralized command" and replaced it with "centralized control." The following is the only explicit reference that was in the previous version of AFDD 1 (Sep 1997) referenced by Baltrusaitis: "Theater and global ranging capabilities impose theater and global responsibilities, which can be discharged only through the integrating function of <u>centralized command</u> under an airman."

[46] Baltrusaitis, 6.

[47] U.S. Air Force, *Air Force Basic Doctrine*, 28.

Ironically, changing the Air Force's position as indicated above does not appear to change the fundamental underlying principles espoused by the current doctrine, but it far better encourages initiative. In light of the ever-increasing complex nature of operations and the speed at which adversaries are adapting, it seems an appropriate time to consider changing the first tenet of air and space power to something more like "Centralized Command and Decentralized Control."

Mission vs. Detailed Command – Command Philosophies for "Control"

Commander's intent and purpose statements are designed to provide general guidance and direction without getting into the details of execution. They specify a desired direction, but allow lower-level echelons some discretion in choosing which road to take toward success. Higher commands have the ability to mark certain courses of action off limits and can use Rules of Engagement (ROE) to constrain decision-making authority if necessary.[48] The power of this command philosophy is that it enables decision-makers at every level to observe their circumstances, analyze and synthesize relevant information to develop a conceptual understanding of the problem, choose an appropriate course of action, and then implement that decision, all the while continuing to observe and question orientation. The control method described is encapsulated within the command philosophy of Mission Command, and the decision-making cycle described is well known in military parlance as Colonel John Boyd's OODA loop (Observe, Orient, Decide, Act), depicted in Figure 3.

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[48] COL Christopher Hickey's Spring 2007 Military Review article, extended the road analogy by using the concept of "Rumble Strips" to describe the "left and right limits" that a commander can provide to subordinates – in addition to providing them with the commander's intent. Christopher M. Hickey, "Principles and Priorities in Training for Iraq," *Military Review.* 87, no. 2 (2007).

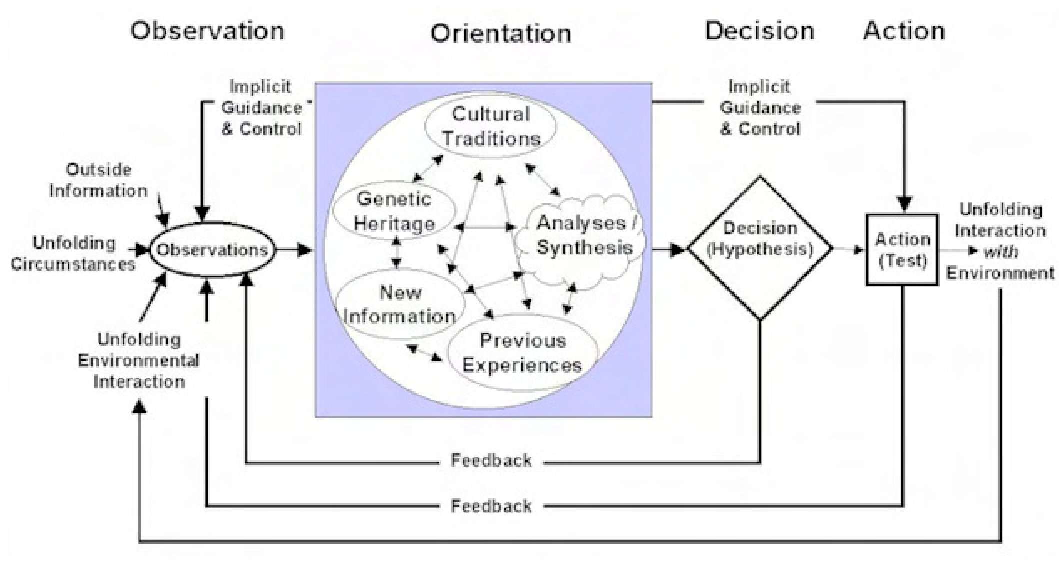

Figure 3. Boyd's OODA Loop[49]

The term "mission command" appears to be well accepted in the British military where it is professed more adamantly than in the United States.[50] However, the philosophy has been increasingly taking root within U.S. military doctrine since Vietnam. It is particularly emphasized in U.S. Army doctrine such as Field Manual 6-0, *Mission Command: Command and Control of Army Forces*. According to FM 6-0, mission command depends upon four key elements for success.[51]

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[49] John Boyd, "Colonel John Boyd, Part 2," http://www.saunalahti.fi/~fta/JohnBoyd_fin_2.htm (accessed January 20, 2008). "Destruction and Creation," an unpublished paper written by Col Boyd provides an insightful look at the philosophical thinking behind his concept of orientation. It suggests that when a theory of how a system works no longer seems to fit, it is time to destroy that theory and create a new mental construct of the system. It is time to construct a new theory to cope with the refined appreciation of reality. John R. Boyd, "Destruction and Creation," http://www.chetrichards.com/author_index.htm (under John R. Boyd) (accessed March 18, 2008).

[50] The Prussians developed the concept of Auftragstaktik or "mission tactics" after suffering humiliating defeats against Napoleon in the early 1800s. The desire was to infuse initiative among subordinates who were empowered and expected to reason beyond explicit orders and laid the foundation for the military strength of the German military in the early twentieth century. The concept has become known as "mission command" within the British and U.S. military.

[51] U.S. Army, *Mission Command: Command and Control of Army Forces*, FM 6-0 (Washington D.C.: Headquarters, Dept. of the Army, 2003), 1-17.

1. Commander’s Intent
2. Subordinate Initiative
3. Mission Orders
4. Resource Allocation

The unifying effect of a clearly articulated “commander’s intent” and the importance of subordinates maintaining a measure of initiative have already been emphasized. “Mission orders,” sometimes referred to as “mission-type orders” are merely the method through which the philosophy of mission command is implemented. Mission orders emphasize commander’s intent and purpose for the mission to provide the “why.” They may also provide the “who, what, where, and when,” but leave the “how” up to the tasked unit. Resource allocation is the manner that commander’s use to ensure that subordinate units have the resources, including information, necessary to fulfill their assigned missions.[52]

The importance of resourcing subordinates with information is becoming increasingly important in today’s dynamic operating environment. One approach is to feed warfighters with information, but this requires dependable communication links and experience to understand what they need to know so it can be “pushed” to them. A second approach is to provide warfighters with the ability to “pull” the information they want, but this again requires dependable communication links and warfighters with experience to know what to look for and where to find it. A third alternative is to give warfighters the resources to collect more information themselves. This option allows warfighters to capitalize on their human senses, explore ideas, test hypotheses, and exploit initiative within the bounds of commander’s intent. It is human-sensor fusion, fostering idea formulation and creativity without fear of an overbearing commander. A key benefit of the third option is that dependable communication links are not required to feed the

[52] Ibid., 1-17,1-18.

information to the warfighter. However, the warfighter must also be resourced with technology that automates much of the analysis process. A fourth, and probably best strategy, is to purse the first three concurrently. Resourcing warfighters with information to enable decentralized decision-making is a central theme of this paper, and an understanding of the science and technology behind MASINT will be offered as one way to inspire ideas for new sensors that can enable warfighters to resource themselves with information.

In contrast to mission command, Army Field Manual 6-0 also discusses an alternative philosophy called Detailed Command. Both mission command and detailed command are “command” philosophies and the difference between them is the style of “control” they promote. Mission command and detailed command focus on decentralized and centralized control respectively. The following is a brief description of detailed command from FM 6-0.

> Detailed command stems from the belief that success in battle comes from imposing order and certainty on the battlefield. A commander who practices detailed command seeks to accomplish this by creating a powerful, efficient C2 system able to process huge amounts of information, and by attempting to reduce nearly all unknowns to certainty. Detailed command centralizes information and decision-making authority. Orders and plans are detailed and explicit, and successful execution depends on strict obedience by subordinates, with minimal decision-making and initiative on their part.[53]

Detailed command implies a greater depth of control. One potential benefit is that tighter control can reduce the risk associated with unsynchronized actions. The greater degree of freedom that subordinates possess, the more likely asynchronous actions will occur. The perceived benefit of detailed command may tempt commanders as technology brings increased communications capabilities to their headquarters. They may believe that they can more efficiently control operations from distant locations without realizing that in doing so they may undermine trust within the organization. The U.S. Army learned this lesson in Vietnam when commanders used radios and airborne command helicopters to directly control actions of troops

[53] Ibid., 1-16.

on the ground instead of using the technology to better resource those same troops with increased information. In the short term, centralized control can sometimes increase efficiency; however, the long-term effect is a potential erosion of trust that undermines the willingness of lower echelons to take initiative and action without explicit orders.[54]

> …helicopters gave them [commanders] a better perspective but also made it easier for them to cross the fine line between helping and interfering. The technology…gave senior officers "a sense of personal presence, influence, and accountability that was both false and disruptive"…[55]

Dietrich Dörner, a renowned German Professor of Psychology, has studied *The Logic of Failure* in complex and non-linear environments. He finds that many people have problems recognizing the higher order effects of their actions. This failure may result from the cognitive realm or may simply be a desire to preserve a "positive view of one's competence."[56] They usually fail to ask questions that would help them understand complex relationships, interactions, and potential unintended consequences.[57] Many commanders in Vietnam probably did not question and did not understand the second and third order effects of their decision to retain a more centralized level of control. Therefore, they could not recognize or avoid the problems caused by their apparently well-intentioned actions, but initiative was being destroyed on the battlefield nonetheless.

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[54] Ibid., 1-20.

[55] David Maraniss, *They Marched into Sunlight: War and Peace, Vietnam and America, October 1967* (New York: Simon & Schuster, 2003), 225.

[56] Dörner, 188.

[57] Ibid., 4.

> Imagination is more important that knowledge. Knowledge is limited. Imagination encircles the world.
>
> – Albert Einstein

Developing Distributed Expertise

The digitization of the battlefield may once again lure commanders toward centralized control with predictable consequences. The development of the Air and Space Operations Center (AOC) since the early 1990s and the increasing ability to quickly move mass quantities of information around the world has many people within the Air Force worried that commanders may take steps toward failure similar to helicopter-bound Army commanders in Vietnam.

The AOC has become the central repository for information in the air component of a JFC's campaign. It is well suited to fuse information together and produce a consolidated picture of the theater air operations. This fusion allows the commander and planning staff to maintain a pulse on the warfighting effort, further shape the air contribution to the campaign, and redirect assets against high priority and time sensitive targets. However, like Army commanders in Vietnam, the AOC must remember that the more removed a control element is from the warfighter, the less effective it can be at imposing order. Separation from action decreases awareness of the friction a warfighter is facing. The power that information fusion brings must be tempered by a measure of trust in the competence of subordinates and the realization that they may not be resourced with the information that the AOC possesses. The challenge is to resource warfighters with information without micromanaging them. Lt Gen Michael C. Short, the JFACC during Operation Allied Force, recollected a particularly memorable moment that highlights the stress and frustration that can result from too much direct involvement from above.

> About 5 o'clock in the afternoon, we had live Predator video of three tanks moving down the road in Serbia and Kosovo. As most of you know, my son is an A-10 pilot, or he was at the time. We had a FAC [Forward Air Controller] overhead and General Clark [Gen. Wesley K. Clark, SACEUR] had the same live Predator video that I had. "Mike, I want you to kill those tanks." I quickly responded, I had something else in mind, "Boss, I'll go after that for you." When shift time came, [Maj. Gen.] Garry Trexler was on the floor, finishing up in the daytime, and [Brig Gen] Gelwix arrived to take the night shift. I was there because the SACEUR wanted those three tanks killed. We had a weapon school graduate on the phone talking directly to the FAC on the radio. The call went something like this: "A lot of interest in killing those tanks, 421. I'd like you to work on it." "Roger." Two or three minutes went by, and 421 clearly had not found those tanks. The young major's voice went up a bit and said, "ComAirSouth, and SACEUR are real interested in killing those tanks. Have you got them yet?" "Negative." About two more minutes went by and the weapons school graduate played his last card. "General Short really wants those tanks killed." And a voice came back that I've heard in my house for the better part of 30 years and he said, "God damn it, Dad, I can't see the f---ing tanks!"[58]

In deciding whether to re-direct aircraft inside of the normal planning cycle, the AOC must weigh the increased risk involved with tasking aircrew already in-flight against the value of the new tasking or target. Airmen will gladly accept this re-tasking if it contributes to the war effort. Their on-board sensors have a relatively narrow field of view, so they often need outside assistance to funnel their search for valid targets. However, if they are routinely sent after ghost targets instead of conducting their pre-planned mission or hitting pre-planned targets, they will begin to question the contribution of their effort, the level of control they are under, and the decision-making role of the AOC.

While technology may give the AOC the ability to obtain a greater degree of theater-level situational awareness than aircrews executing tactical missions, personnel at the AOC must recognize that they will never be able to fully grasp, in real time, the rich details of reality that a warfighter is experiencing. Only warfighters can fuse the sensor information with what their human senses and experiences tell them about their operating environment. Aircrews do not fear

[58] Michael C. Short, "AFA Air Warfare Symposium 2000," Air Force Association, https://www.aef.org/AEF/pub/short200.asp (accessed December 23, 2007). The cited text is a portion of a transcribed presentation given by Lt Gen Short. The callsign of the A-10 was probably not actually 421, since that is a very non-standard format. It is most likely the result of a transcription error.

being re-tasked, what they fear is that the AOC will attempt to direct their tactics, monitor their every move, and question each action they take. The AOC can coach from the sideline, but should not try to play in the game. It can resource the warfighter, but should stay out of the cockpit. This is the concept behind Mission Command and it supports both the concept of decentralized control and decentralized execution. Decentralized control encourages and usually implies decentralized execution, but decentralized execution does not imply decentralized control.

If the AOC can focus on using technology to resource tactical warfighters with information, the concept of mission command can be maintained and erosion of trust can be avoided. Nevertheless, it is equally important to reflect upon warnings regarding too much information.

> The more the available information, however, the longer the time needed to process it, and the greater the danger of failing to distinguish between the relevant and the irrelevant, the important and the unimportant, the reliable and the unreliable, the truth and the false.[59]

In addition to this note of caution, Van Creveld offers a solution to the seemingly "self-defeating dilemma." Training, practice, and experience are required to develop what Napoleon describes as "a superior understanding," "relying no less on intuitive judgment than on rational calculation."[60]

Training, practice, and combat experience provide the military professional with a base of knowledge to draw upon when conducting rational calculations. More importantly though, they offer the professional a set of experiences on which they can reflect in order to be prepared to make intuitive (not instinctive) judgments when time does not allow rational calculation.[61]

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[59] Van Creveld, 267.

[60] Ibid.

[61] In this context, intuitive judgments are derived from reflective thought and experience-based learning that enables quick decision-making. The desire is to differentiate from biological instincts that people are born with, such as recoiling from pain. In addition to some of the other sources cited in this section, Robert Pirsig's 1974 book, *Zen and the Art of Motorcycle Maintenance: An Inquiry into Values*, provides an excellent opportunity to read and think about the value of self-reflection and learning.

"Mistakes are essential to cognition" – they should be expected, tolerated, and certainly reflected upon.[62]

Careful reflection allows a military officer to develop the qualities of Clausewitz's "military genius" or Gary Klein's "experts" which he describes in *Sources of Power: How People Make Decisions*. Experience allows these elites to skillfully recognize familiar aspects of complex situations and quickly develop "high-quality" courses of action. "Experts can perceive things that are invisible to novices."[63] Klein's research found that the first course of action reasonably considered by an expert is usually as good, or nearly as good, as the ones they choose when time is not a factor.[64] Klein calls this skillful application of experience Recognition-Primed Decision-making (RPD).[65] Similarly, Clausewitz notes that the military genius should "in all doubtful cases stick to one's first opinion and refuse to change unless forced to do so by a clear conviction."[66] Van Creveld simply refers to these decisions as emanating from intuitive judgment, but it is clear that they each recognize the value of experience, training, and practice.[67]

It seems clear that the best way to teach airmen how to resource each other and cope with increasing levels of information, is to increase awareness, familiarization, and peacetime access to information sources; and to let them practice as much as possible . The intelligence community and its products, such as MASINT, must be infused into more routine training missions and exercises if the U.S. realistically expects integration with warfighters in major combat operations. There is an endemic need to reduce former Secretary of Defense Donald Rumsfeld's "known,

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[62] Dörner, 199.

[63] Gary A. Klein, *Sources of Power: How People Make Decisions* (Cambridge, Mass.: MIT Press, 1999), 175.

[64]Ibid.

[65] Ibid., 16.

[66] Clausewitz, 108.

[67] Van Creveld, 267.

unknowns" and "unknown, unknowns" with regard to foreign, but also domestic capabilities.[68] The military has long professed, "train like you fight," because the more important reality is that soldiers, sailors, airmen, and marines will "fight like they trained."

Information Resourcing

Speed and freedom to maneuver in the third dimension enables airpower to target nodes within an enemy system that are out of the reach of land and naval surface forces. This is one of the foundations upon which Col John Warden proposes, "air may be the key force" in many operations.[69] This nature also tends to spread airpower's effects and assets across great distances. As a result, air power is intrinsically a force engaging in distributed operations. The prevalence of precision munitions, concerns over collateral damage, trends toward increased dynamic targeting, and the concept of massing effects instead of forces; increase the complexity and distributed nature of air operations.

Hundreds of sorties were once required to ensure a high probability of mission success, accuracy was often measured in kilometers, and strategies like "island hoping" were required to put aircraft within range of their targets. Today, even a single flight of fighters can simultaneously target over a hundred widely dispersed targets from over sixty nautical miles

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[68] Hart Seely, "The Poetry of D.H. Rumsfeld: Recent Works by the Secretary of Defense," Slate, http://www.slate.com/id/2081042 (accessed December 20, 2007). Former Secretary of Defense Donald Rumsfeld made the following memorable remark on February 12, 2002, during one of his infamous press conferences: "As we know, there are known knowns. There are things we know we know. We also know, there are known unknowns. That is to say, we know there are some things we do not know, but there are also unknown unknowns, the ones we don't know, we don't know." – quoted from source previously listed. *The Black Swan,* by Nassim Taleb, offers phenomenal insights on the impact of "unknown, unkowns." Nassim Taleb, *The Black Swan: The Impact of the Highly Improbable* (New York: Random House, 2007).

[69] John A. Warden, *The Air Campaign: Planning for Combat* (Washington, DC: National Defense University Press, 1990), 149.

away with an accuracy measured in feet, and aerial refueling can extend their range to the point that human fatigue is the limiting factor.[70]

The challenge of resourcing tactical echelons of airpower has shifted from providing sufficient material/aircraft to supplying timely information/target coordinates. Larger and more complex mission sets demand more information to plan and carry them out.[71] Application of technology has increased the complexity of operations and driven increased demands for information in an interminable desire to eliminate uncertainty.[72] This poses an increasing challenge to any command-and-control system that attempts to maintain centralized control.

A well-staffed AOC with adequate time to study an adversary can probably generate enough ground targets for the first few days of a major combat operation. However, the increasing fluidity of both friendly and enemy ground forces will likely overwhelm attempts at centralized control beyond that. Moreover, the greater the effort to centralize control, the more lucrative a target the AOC becomes for enemy kinetic and non-kinetic attacks.

Saddam Hussein’s ability to launch direct attacks against Lt Gen McKiernan’s CFLCC headquarters (Coalition Forces Land Component Commander) in the opening days of Operation Iraqi Freedom should have sounded a loud warning. A single successful attack against the AOC could be both physically and psychologically devastating, especially to an organization accustomed to centralized control, and future attacks are likely to come in non-traditional fashions.

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[70] Ryan Hansen, "Small Diameter Bomb Timeline Remains on Schedule," Air Armament Center Public Affairs, http://www.afmc.af.mil/news/story.asp?id=123017916 (accessed November 11, 2007). Recent fielding of the GBU-39, Small Diameter Bomb (SDB), enables a significant increase in the number of weapons that can be carried by aircraft such as the F-15E. Each F-15E has the capability to carry 28 GBU-39s, so a four-ship could conceivable target 112 individual targets with a GPS guided munition – simultaneously.

[71] Van Creveld, 265.

[72] Ibid.

Centralized control provides an obvious Clausewitzian center of gravity and a cunning adversary will likely pursue asymmetric means to deny, destroy, or degrade its effectiveness.[73] Centralized command with decentralized control of distributed operations, disperses decision-making and provides a “redundancy of potential command.”[74] – in Dörner’s words, “many individuals who are all capable of carrying out leadership tasks within the context of the general directives.”[75] These general directives help provide the framework that keep distributed operations from competing with each other.

The need to resource combat aircraft with information is becoming the critical capability needed to sustain airpower. Aircrews have accepted the AOC’s role in directing them toward targets, because the AOC often has access to information that aircrew do not.[76]

The Air Force has spent much of the past two decades trying to increase the speed at which it can execute the tactical OODA loop and hit emerging targets before they disappear or lose their value. The basic concept of operations has been to funnel huge streams of data from ISR platforms to analysts that quickly pour over the information looking for potential targets so they can be coordinated through a centralized control element for approval, then direct aircraft to

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[73] Ibid., 3.

[74] Fredmund F. Malik, *Strategie des Managements Komplexer Systeme: Ein Beitrag zur Management-Kybernetik Evolutionarer Systeme*, Schriftenreihe Unternehmung und Unternehmungsfuehrung, Bd. 12 (Bern: P. Haupt, 1984). This original source is only available in German. Dietrich Dörner, in *The Logic of Failure*, pg 161, cites Malik as the source for the phrase “redundancy of potential command.”

[75] Dörner, 161.

[76] Survey results indicate that aircrews prefer to make targeting decisions based upon information from on-board sensors verses off-board sensors in both dynamic and non-dynamic targeting environments. However, the ratio of that preference was dramatically greater for non-dynamic targeting environments (17:1). In dynamic targeting environments, the ratio was 2:1. Two possible explanations are: 1) Aircrews do not feel that they have access to the information needed to make decisions in rapidly changing environments. 2) Aircrews may feel a level of discomfort or apprehension about making decisions in dynamic environments. Either and both of these possibilities should be addressed if flexibility is to be maintained in an increasingly complex and adaptive world. Reference questions #23 and #24. The results are graphically depicted in Appendix A, and the actual survey is depicted in Appendix B.

acquire and strike those targets. Find, Fix, Track, Target, Engage, and Assess (F2T2EA) has become the way the Air Force has structured the “kill chain” into a six-step linear process.

The sheer magnitude of information available from today’s ISR platforms and the limited human resources available, has forced the Air Force to look at ways for computers to aid the processing of data. Computer algorithms sift through downloaded data streams and focus human attention on areas of interest. Methods to process and compress data on-board sensor platforms have been developed to increase the effective bandwidth available for downlinks. Machine-to-machine communication has also been emphasized to increase the speed of information flow and reduce the prospect of human errors contaminating datastreams. The AOC has been the center of focus in this sea of change and it has depended on relatively small number of dedicated ISR platforms to satisfy information requirements.

ISR platforms have long been Low Density / High Demand (LD/HD) assets. In the wake of September 11, 2001 and the ensuing Global War on Terrorism (GWOT), demands for ISR have certainly not decreased. There has been little effort to increase the number of manned ISR platforms, and even though the number of unmanned ISR assets has been steadily increasing over the past decade, there is no indication that the Air Force believes unmanned ISR platforms can avoid the same LD/HD fate.[77] As Van Creveld theorized, there is an insatiable desire to reduce uncertainty.[78]

The desire for ever-increasing information has led to some creative uses for already fielded capabilities. In the months leading up to Operation Iraqi Freedom (OIF), some people started to consider the idea of supplementing traditional ISR, such as the U-2, with video images

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[77] U.S. Air Force, "General Provides Clarification of UAV Use," Air Force Link, http://www.af.mil/news/story.asp?storyID=123050533 (accessed November 11, 2007). Approximately 90% of survey respondents indicated that they believe manned traditional ISR assets are likely to remain LD/HD assets. Furthermore, 60% of respondents believed that unmanned ISR assets are also expected to remain LD/HD assets. Reference questions #15 and #16. The results are graphically depicted in Appendix A, and the actual survey is depicted in Appendix B.

[78] Van Creveld, 265.

obtained from fighter aircraft. Targeting pods, traditionally used for guiding Laser Guided Bombs (LGBs), were becoming more capable with the fielding of advanced targeting pods, such as LITENING, and the decision to procure large numbers of SNIPER pods. The concept of using these pods in a non-traditional manner may have begun during Operation Allied Force, but at least partial credit has been given to Brig Gen William Rew in the months leading up to Operation Iraqi Freedom.[79] He accepted the fact that the targeting pods did not have the inherent resolution of a U-2, but could offset that disadvantage with the ability of fighters to maneuver closer to reconnaissance targets and underneath cloud layers that might obscure the line of sight from sensors on traditional ISR assets.[80] Targeting pods filled a niche and allowed traditional ISR assets to focus on other targets. Brig Gen Rew's concept became known as Non-Traditional ISR, or NTISR, but the sensors being used were never designed to feed into the intelligence collection process.[81] Some fighter pilots may have initially been alarmed by the prospect of becoming manned Predators, a reconnaissance UAV (Unmanned Aerial Vehicle), but the NTISR concept slowly gained traction and continues to expand in the limited conflict environments of Iraq and Afghanistan.[82]

In the absence of major air combat operations and higher priority taskings, combat aircraft including fighters, bombers, and attack aircraft are routinely providing reconnaissance support to troops on the ground.[83] They are also utilizing another technological device called

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[79] John A. Tirpak, "Eyes of the Fighter," Air Force Magazine Online, http://www.afa.org/magazine/jan2006/0106fighters.asp (accessed November 27, 2007).

[80] Ibid.

[81] Only 10% of survey respondents believed that NTISR was a planned capability envisioned when currently fielded sensors were designed for "shooter" aircraft. Additionally, only 10% indicated that they thought NTISR was well integrated into the intelligence collection process, while 85% believe that future sensors developed for "shooter" platforms should be better integrated into the intelligence collection process. Reference questions #11, #12, and #13. The results are graphically depicted in Appendix A, and the actual survey is depicted in Appendix B.

[82] Tirpak.

[83] Ibid.

ROVER – Remote Operated Video Enhanced Receiver. ROVER provides the ability to transmit real time video directly from sensors on many combat aircraft and UAVs directly to warfighters on the ground. This capability has dramatically increased the interaction and trust between air and ground forces and increased the efficacy of Close Air Support (CAS) missions.[84]

While conducting convoy escort missions, airmen are performing a limited command-and-control function. They are resourcing ground forces with information, without telling them how to do their mission. Similarly, during CAS missions, ground forces are executing a limited command-and-control function by resourcing aircraft with targeting information and restrictions, but they are not telling the aircrew how to fly their planes. These operations represent a high degree of decentralized control of distributed operations.

While not the original intent, NTISR has helped facilitate decentralized control of distributed air operations, under the centralized command of a JFACC even when providing direct support to ground forces. When the AOC redirects combat aircraft to perform Battle Damage Assessment (BDA) or other NTISR missions, it should strive to issue Mission-Type orders that avoid providing details on how to execute the mission. By doing so, the AOC can avoid eroding trust, stifling initiative, and creating perceptions of over-centralized control. The AOC can continue to provide a measured degree of centralized control through traditional means, such as the Air Tasking Order (ATO) and Time Sensitive Targeting (TST) Cell, in an Air Force that accepts “Centralized Command and Decentralized Control of Distributed Operations” as a tenet of air and space operations.

[84] Julie Weckerlein, "ROVER Gives Joint Force New Vision," Air Force Print News, http://www.af.mil/news/story_print.asp?id=123013585 (accessed November 11, 2007).

Shifting Acquisition Strategy: Distending NTISR amid Asymmetric Threats

Equipping traditional ISR platforms with Hellfire missiles and conducting NTISR with combat aircraft are two examples of novel approaches taken to close the gap between Intelligence and combat operations. Neither was a direct result of requirements laid out in formal acquisition programs. However, the recent fielding of the MQ-9 Reaper is the direct result of a GWOT initiated acquisition program to develop an unmanned hunter-killer platform. It is a vast improvement over MQ-1 Predators equipped with Hellfire missiles because its designers had a new set of requirements to consider in the design of a new weapon system.[85]

If the Air Force’s first deputy Chief of Staff for ISR gets his way, the MQ-9 is just another step towards merging Operations and Intelligence into a stronger and more unified team. Lt Gen Deptula, a fighter pilot charged with leading the transformation of ISR, is adamant about increasing the integration of sensor capabilities on traditional combat aircraft into the overall intelligence framework. He notes that while the F-22 is predominantly an air-superiority fighter, its sophisticated array of sensors also brings a tremendous amount of ISR capability to the fight. “It's not just an F-22, it's an F/A/B/E/EA/RC/AWACS (airborne warning and control system)-22.”[86] General Deptula enjoys touting the NTISR capabilities of the F-22 but hopes that within the next decade, people will stop making references to NTISR. He sees a future where all Air Force platforms are integrated in the ISR process. This will necessitate increased communication between organizations that have typically produced ISR assets and organizations charged with the acquisition of combat aircraft. Some degree of stovepiping will likely always exist, but conduits must be created to make them more porous.

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[85] U.S. Air Force, "MQ-9 Reaper Unmanned Aerial Vehicle," Air Force Link, http://www.af.mil/factsheets/factsheet.asp?fsID=6405 (accessed December 1, 2007).

[86] Kelly White, "Intel Deputy Highlights ISR Transformation Progress," Global Air Chiefs Conference Public Affairs, http://www.af.mil/news/story.asp?id=123069682 (accessed December 1, 2007).

Lt Gen Deptula's vision promises many benefits for the Air Force. It increases the overall ISR capability and enables airmen to harness the increasingly complex battlespace with more diversified and distributed sensors. Diversity within a complex adaptive environment provides resiliency and helps facilitate the exploration of new alternatives.[87] However, centralized control must be de-emphasized or it could threaten creative thought and initiative as it has in the past. Diversity, creative thinking, and the ability to take initiative are all vital elements needed to drive toward success in complex adaptive environments, but information is the resource that fuels these elements.

In an ideal world, all platforms would be networked together and the information they gather would be automatically digitized. They would share information using machine-to-machine communications to increase speed and reduce human error while keeping people in the loop to make informed decisions. Components of Kometer's CAOS would both "post" and "smart-push" information so that other components could access or "pull" the data they need. Awareness of information needs would result from established relationships and be based upon experience and lessons learned in both virtual and real world training exercises that integrate more aspects of national power. All of the information would flow across secure communications networks to prevent access by adversaries who might use the information for nefarious purposes.

The problem is that rivals will do all they can to insure a non-ideal world and increase the fog and friction of war. Information is a key resource and adversaries are likely to seek ways to corrupt data-gathering processes and deny or degrade the intelligence gleaned from it.[88] Information Operations (IO) is not a uniquely American concept. Many have noted the

[87] Robert M. Axelrod and Michael D. Cohen, *Harnessing Complexity: Organizational Implications of a Scientific Frontier* (New York: Basic Books, 2000), 108.

[88] Survey respondents indicated 45:1 that they believe future adversaries are likely to increase the use of deception techniques (camouflage / concealment / decoys) to disrupt ground-targeting efforts. Reference survey question #25. The results are graphically depicted in Appendix A, and the actual survey is depicted in Appendix B.

tremendous success that Al Qaeda has had employing the media in a robust IO campaign against the United States. While this has frustrated efforts to combat militant extremists and terrorism, the threat posed by a more sophisticated adversary could be much more severe. A kinetic attack on an AOC would no doubt have a tremendous affect on air operations, but at least it would be clear that an attack had occurred. A Computer Network Attack (CNA) could be much more devastating, especially if it leaves no indication that something is awry. Offensive IO is not new. It is as old as the human concept of lying and deceit, but its sophistication is increasing and technology provides new tools for both combating and employing IO.

In Vietnam, American ground forces enjoyed a tremendous technological advantage over their adversary, but the North Vietnamese recognized the vulnerability of American communications networks and attempted to use this vulnerability to their own advantage.

> During a fire fight in Lam Dong province in 1967 members of a MACV [Military Assistance Command Vietnam] advisory team requested artillery support. As the Fire Direction Center prepared to direct the mission, they "received another call in clear distinct English requesting the fire be shifted to a different set of grid coordinates. Luckily the team overheard the request and were (sic) able to contact the Fire Direction Center in time to prevent an artillery attack on their own position!"[89]

If future rivals perceive a similar vulnerability, they are likely to employ much more sophisticated techniques due to the growing availability and anonymity of affordable technology.

Unrestricted Warfare, a book written by two Chinese Colonels and translated by the CIA's Foreign Broadcast Information Service (FBIS), espouses a theory termed "beyond-limits combined war."[90] The central theme is that non-military means are the best way to attack the United States and suggests targeting information hubs within multiple echelons of the American system. The authors do not suggest that there are "no limits" in warfare. Instead, they advocate

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[89] Ronald H. Spector, *After Tet: The Bloodiest Year in Vietnam* (New York: The Free Press, 1993), 81.

[90] Liang Qiao, Al Santoli, and Xiangsui Wang, *Unrestricted Warfare: China's Master Plan to Destroy America* (Panama City, Panama: Pan American Publishing Company, 2000), 175.

going “beyond” normal boundaries to conduct a systemic attack on multiple components of an enemy’s system.[91] Not surprisingly, many people suspect that the recent compromise of a Department of Defense e-mail system was the result of a computer network attack by the Chinese Army. On September 4, 2007, the Pentagon acknowledged the attack had occurred in the spring but declined to comment on possible Chinese Army involvement.[92] The threat of asymmetric attacks is real and the increasing public acknowledgment of the potential danger is one indicator.

A recent U.S. News and World Report article highlighted the vulnerability of homeland infrastructure after the Department of Homeland Security (DHS) demonstrated the ability to cause a power plant control system replica to destroy itself using a few computers and an internet connection.[93] The test was also covered by a television news report on CNN and more clearly outlined the potential impact of a deliberate computer network attack. CNN’s coverage included portions of an interview with Robert Jamison, a deputy undersecretary at DHS, who emphasized that the significance of this test was that it showed that a computer network attack could cause physical damage.[94] The U.S. News and World Report article quoted U.S. National Counterintelligence Executive, Joel Brenner, saying that U.S. computer network are under “persistent attack” and underscored the significant nature of network attacks by pointing to the impact from a large-scale cyberattack against Estonia’s government networks in May 2007. The computer network attacks shut down major portions of the Estonian government and banking system.

The writing is on the wall. The Department of Defense must make serious efforts to secure its communications networks. However, it would be foolish to place too much faith in this

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[91] Ibid., 155.

[92] David Morgan, "Pentagon E-Mail System Breached," Reuters, http://www.msnbc.msn.com/id/20586967/wid/11915829&GT1=10357 (accessed September 4, 2007).

[93] Kevin Whitelaw, "A High-Tech Achilles Heel," *U.S. News & World Report*, November 5, 2007, 39.

[94] Jeanne Meserve, *Anderson Cooper 360* (CNN).

single preemptive strategy. It must also make serious efforts to secure the information collection, processing, and analysis systems. Diversifying and distributing these components may not be "cost efficient," but would produce resiliency and stifle an enemy's targeting strategy.

Satellite communications and space-based ISR platforms are expensive. Orbital mechanics restrict their flexibility, but the benefit of being able to operate them with impunity has historically offset the cost and predictability factors. However, the growing dependence upon these limited assets has led other nations to pursue methods to counter the capabilities of U.S. satellites. A recent and direct challenge came, not surprisingly, from China in January 2007 when they apparently conducted a successful Anti-Satellite (ASAT) test. The test sparked renewed discussion about the ability to depend on access to space-based platforms. As noted by the Air Force Chief of Staff, Gen Moseley, "…the recent Chinese ASAT test illustrates that space is no longer a sanctuary."[95]

The Air Force is currently highly dependent on an insufficiently diverse set of ISR platforms. The intelligence derived from sensors on these platforms is sent to the AOC, which develops an ATO and intelligence products to support air operations. The process is extremely communication-dependent and highly dependent upon a few key nodes: Traditional ISR and the AOC. Adversaries have targeted information systems in the past, will probably do so in the future, and traditional ISR and the AOC are targets they will likely focus on. The attacks may not

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[95] T. Michael Moseley, "Chief's Scope: The High Ground," http://www.af.mil/specials/scope/highground.html (accessed December 1, 2007). As this Monograph is being completed, the U.S. is facing questions in response to the decision to shoot down a failed U.S. satellite (February 2008). The U.S. has gone to extraordinary efforts to emphasize that the shoot down was conducted in a manner that quickly reduced the amount of debris left in space and the decision was driven by safety concerns surrounding the re-entry of a frozen hydrazine fuel tank onboard. While many people will likely question the motivations in the wake of an earlier (January 2007) Chinese test, it is hard to ignore that the successful Chinese test probably made the decision easier for the U.S. government to make.

be direct. Indirect targeting such as on communication links may prove easier, and the prospect of being able to conduct non-attributable computer network attacks makes it even more enticing.[96]

If securing key information nodes and communication networks is one approach to ensure an ability to resource airmen with information, a second and complementing strategy would be to diversify the sources of ISR and feed information directly to combat aircraft executing tactical missions – often referred to as "sensor-to-shooter." The MQ-9 is a nice blend of ISR and combat airpower and partially closes the gap, but it is still fundamentally dependent on reliable communications networks. Since the MQ-9 is unmanned, the airmen that control them can only process information that is datalinked to them and they need these same datalinks to maintain control of the UAV.

Embracing Deptula's vision and extending ISR capabilities to every platform makes sense. It increases, diversifies, and distributes ISR capabilities so they are more difficult to attack. Increasing the sensor capability of manned combat aircraft, resources aircrews with information to supplement what their other senses naturally tell them and empowers them to accomplish their missions in a communication denied environment. In this type of environment, the Air Force will have to depend on decentralized control of distributed operations taking initiative to execute "mission orders" while complying with ROE.

Traditional ISR sensor technologies must migrate to combat aircraft quicker than they have in the past. The idea is not to replace dedicated ISR, but to supplement it and capitalize on the resiliency that accompanies a diversified set of capabilities. Combat aircraft sensors must be modified or designed to facilitate wide-area surveillance that directs an aircrew's attention to potential target areas. They must counter the growing sophistication of decoys, aid in the positive

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[96] Ninety-one percent of survey respondents indicated that they believe future adversaries are likely to target U.S. communications and reach-back capabilities to reduce the effectiveness of air operations. Reference question #14. The results are graphically depicted in Appendix A, and the actual survey is depicted in Appendix B.

identification of targets, prevent fratricide, provide more immediate BDA, produce 3-dimensional (3D) target images, and digitize/store data in a manner that facilitates easy integration with intelligence networks and other weapon systems, including the AOC. While this list is certainly not complete, it is a beginning and is based upon existing sensor technologies that remote sensing communities have been developing for many years. MASINT science and technology must be better understood by the warfighter, and the ISR community must look for ways to share not just the products, but also the technology developed for collecting information.

> Nothing should be neglected to acquire a knowledge of the geography and the military statistics of other states, so as to know their material and moral capacity for attack and defense as well as the strategic advantages of the two parties.
>
> – Antoine Henri Jomini, *The Art of War*

Remote Sensing (MASINT)

MASINT is a broad field of intelligence that capitalizes on the science of remote sensing. It is responsible for deriving technical intelligence from devices such as those that detect particle and wave energy, including mechanical and electromagnetic waves. Gravimetric, magnetic, acoustic, seismic, electromagnetic, particle, and other sensors are utilized to gather data, present information, and produce intelligence products that can provide warfighters with an increased understanding of the operational environment.

Every soldier, sailor, airman, and marine must become an integral part of the information gathering process. Air, land, sea, and sub-surface platforms each have the potential to contribute to the collective ISR process. Technologies should be applied that not only help integrate them into the broader ISR system, but also resource tactical units with decision-quality information to insure a measure of resiliency among distributed operations.

Due to their ability to seize the "high-ground" and quickly maneuver throughout the operational environment, air and space operations are uniquely positioned to collect remote sensing data. Electromagnetic waves, which usually require line-of-sight for data collection, are one source of MASINT data that has been particularly exploited for decades, but tactical implementation of emerging technologies has stagnated. While radar and Infrared (IR) sensors have long been employed on tactical aircraft, the potential need to resource aircrew with direct access to information requires a reexamination of what is desirable and currently, or projected to be, feasible. For decentralized control of distributed air operations to be effective in an environment with adversaries capable of degrading communications networks, aircrew need to become aware of currently existing MASINT capabilities, integrate them into training exercises, and identify sensor technologies that could be beneficial if fielded directly on combat aircraft.

A fundamental premise behind MASINT is that every material has an electromagnetic signature that results from a combination of reflected and emitted energy. Observable characteristics, which include amplitude, spectrum (frequency/wavelength), phase, and polarization, can be measured to estimate performance characteristics or help classify an object.[97]

Electromagnetic signatures are like fingerprints that can identify objects well beyond the capability provided by imaging sensors that depend solely on spatial resolution. The signatures can be matched against records to reveal material properties, chemical composition, range, temperature, and other characteristics that can unambiguously identify a target, or like fingerprints in criminal investigations, they can be assessed in conjunction with other information to reduce or filter out potential suspects.

The power of "sensor-fusion" and "all-source intelligence" is the ability to synthesize data from various sources. This has traditionally been conducted by intelligence analysts, but there is no reason to suspect that aircrew would not also benefit from the ability to fuse data from multiple sensors. The key is finding ways to automate much of the process and fielding sensors able to feed aircrew with timely information about their environment from a greater portion of the electromagnetic spectrum.

Traditionally, sensors have been designed to gather and collect energy across a single wavelength region, but Multi-Spectral (MSI) and Hyper-Spectral (HSI) Imaging sensors are composed of multiple, dozens, hundreds, or even thousands of sensors grouped together, each measuring the energy collected over a very small wavelength region. The data is then combined to produce a composite signature and potentially distinguish very specific objects, such as the types and health of crops in a foreign country,[98] the type of gas plumes being emitted from a

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[97] Howard Evans II, "Fundamentals of MASINT," in *OENG 530 Course Text - Summer 2006* (Wright-Patterson Air Force Base, OH: Department of Engineering Physics, Air Force Institute of Technology, 2006), 7.

[98] Ibid.

site,[99] and more tactically, the material, kind of paint, or armor on a tank under camouflage netting.[100]

The Defense Advanced Research Projects Agency (DARPA) is already demonstrating the ability to conduct real time fusion of multispectral data into a visually interpretable image, and the goal of the MANTIS program (Multispectral Adaptive Networked Tactical Imaging System) is to field the capability within a soldier's helmet. However, the real power of fielding multispectral sensors on tactical platforms lies beyond mere imaging and the human brain's innate ability to comprehend visual images. Dependable automated target recognition assistance could be the future, and the additional computer processing capability able to be carried on aircraft brings the possibility of exploiting this potential.

Figure 4 shows an image from research at Michigan Technical University. It illustrates a civilian application of hyperspectral imaging – identifying plant species. Similar techniques could locate illicit crops in Colombia or assess crop health in potentially unstable places like North Korea.

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[99] David J. Williams et al., "Detection and Identification of Toxic Air Pollutants Using Airborne LWIR Hyperspectral Imaging," in *SPIE*, ed. M. Larar Allen, Suzuki Makoto, and Tong Qingxi (SPIE, 2005), 134-141.

[100] James Lange, "Multispectral and Hyperspectral MASINT Exploitation," in *OENG 533 Course Text - Fall 2006* (Wright-Patterson Air Force Base, OH: Department of Engineering Physics, Air Force Institute of Technology, 2006). The actual source is from a videotaped presentation of Dr. Lange that was designed to accompany the course text.

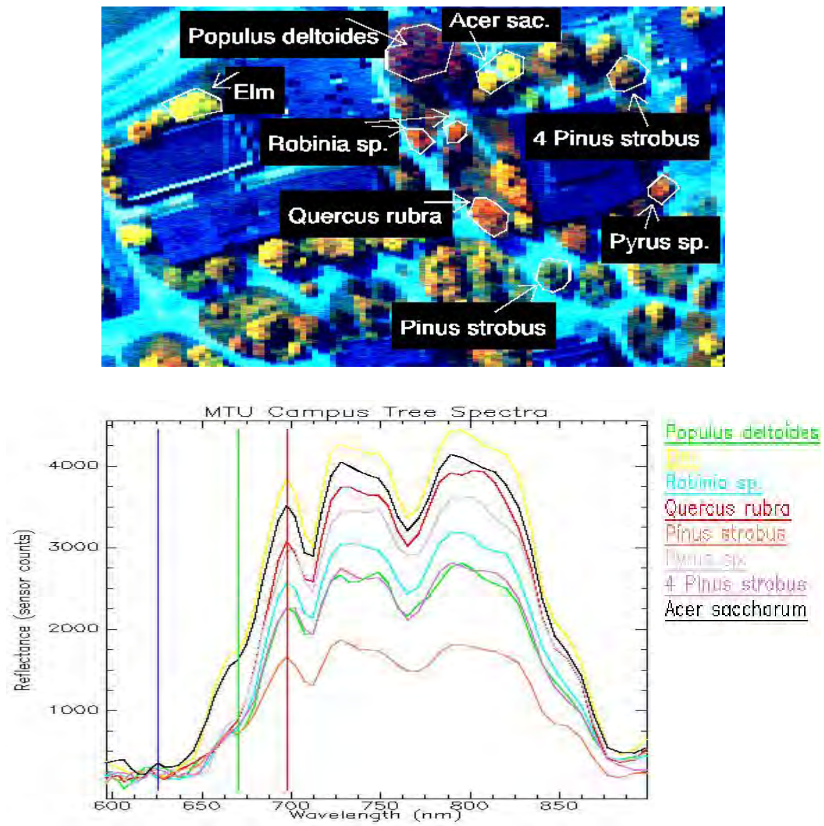

Figure 4. Hyperspectral Image Showing Vegetation at Michigan Technical University[101]

The top image is a false color composite of hyperspectral data collected in the visible and lower infrared region. The graph under the image represents the relative reflectance of various types of vegetation as a function of wavelength. Knowledge of the spectral reflective signatures of several types of vegetation around the campus allows various trees in the top image to be identified, and precise computer analysis allows finer detailed resolution than can be visually depicted by the color distribution on the composite image. The vertical lines in the image show the wavelength that was assigned to each of the primary light colors to create the false color composite. Note: The colors on the lower chart correspond to the title on the right of the graph; the legend colors do not correspond to the false color composite image at the top of the figure.

A more militarily significant application of HSI is depicted in Figure 5 and it shows the passive detection of a military vehicle parked under camouflage netting. If sensors are not looking at the visible spectrum, artificial camouflage may actually highlight an enemy's location.

[101] Drew Pilant, "Spectral Imagery: Vegetation and Human Features in Airborne Hyperspectral Imagery of Michigan Technological University Campus," Department of Physics / Remote Sensing and Ecosystem Science Institute, Michigan Technological University, http://www.geo.mtu.edu/~anpilant/rsi/rsi_hyperspectral/mtu/mtucampus.html (accessed September 27, 2007).

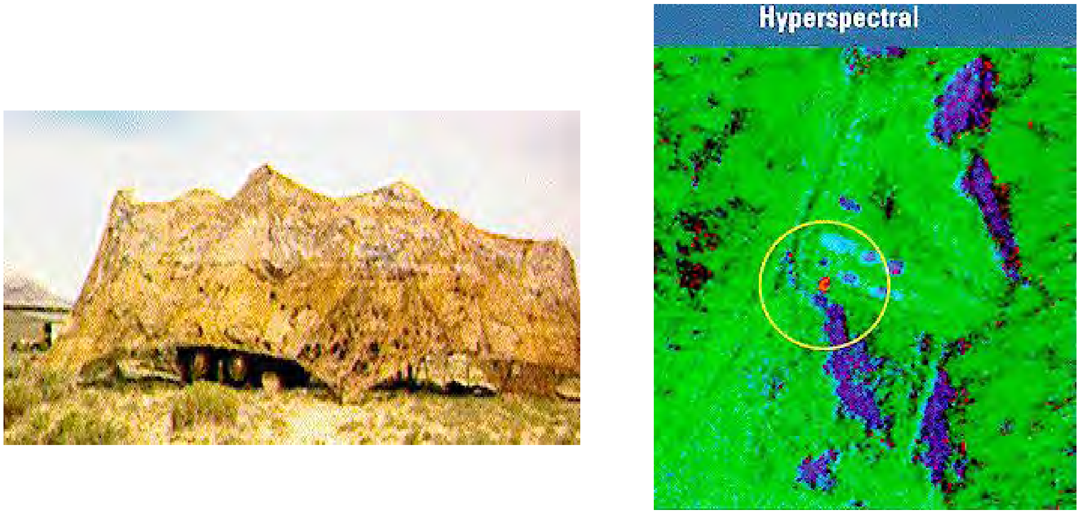

Figure 5. Hyperspectral Target Detection[102]

Left: A military vehicle parked under camouflage netting which disguises the vehicle in the visible spectrum. Right: An aerial view of the camouflaged vehicle and surrounding area using a hyperspectral sensor. The false color image allows the camouflage netting to be clearly located as shown by the red pixels circled above. The ability to analyze the reflective signature from the scene at hundreds of individual wavelengths allows the man-made netting to be distinguished; even the type of paint on the vehicle under the netting may be determined from the reflected energy escaping through the holes in the netting.

Radar (RAdio Detection And Ranging) is another common MASINT sensor. It has been used successfully since World War II to resource decision makers with information, but signal-processing techniques have transformed the manner in which it is employed. Unlike many passive sensors that depend on detecting reflected solar energy, radars are active sensors. They usually transmit their own source of energy, and the wavelengths are generally long enough to prevent scattering by rain, clouds, dust, and other atmospheric obscurant. These unique characteristics, as well as the ability to accurately measure time and phase shifts, makes radar an all-weather, day-

[102] Intelligence Research Program, "Hyperspectral Imaging," Federation of American Scientists, http://www.fas.org/irp/imint/hyper.htm (accessed September 27, 2007).

or-night sensor able to measure range and velocity with great accuracy and even produce so-called radar images using a technique known as Synthetic Aperture Radar (SAR).

Developed in the 1950s, SAR takes advantage of the pulse-to-pulse comparison of radar energy collected by moving radars to produce a synthetic aperture, or virtual antenna, large enough to produce fine azimuth resolution.[103] SAR imaging capabilities have been incorporated on a few combat aircraft for nearly two decades, but signal-processing techniques have rapidly improved and images can now be produced with a quality that can often be confused with electro-optical images. Faster processing and more accurate timing techniques now permit the collection of high fidelity information that allows 3-dimensional (3D) modeling, terrain elevation mapping (radar interferometry), and more accurate weaponeering against imaged targets. Figure 6 provides an example of a typical SAR image of the Pentagon as well as a 3D image created of the U.S. capital building and surrounding area by sensors existing in the mid-1990s.

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[103] Walter G. Carrara, Ron S. Goodman, and Ronald M. Majewski, *Spotlight Synthetic Aperture Radar: Signal Processing Algorithms*, The Artech House Remote Sensing Library (Boston: Artech House, 1995).

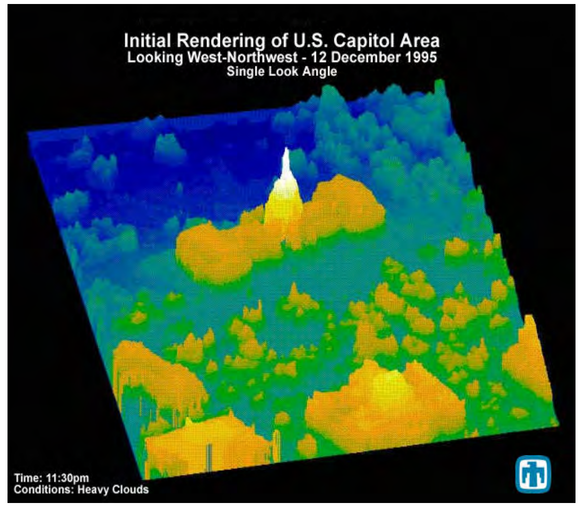

Figure 6. Synthetic Aperture Radar (SAR) Imagery[104] and 3D Capability[105]

Left: A 1-meter resolution SAR image of the Pentagon, showing roads, bridges, walkways, cars, and even trees. The image provides an indication of the fidelity and military application of unclassified SAR imaging. Right: A 3D depiction of the U.S. Capital building and surrounding area created with SAR techniques at 11:30pm, on a night with heavy cloud cover. This image demonstrates the all-weather, day/night capability of SAR to provide accurate elevation data that is critical for many military applications. Since SAR imaging uses wavelengths significantly longer than most obscurants (molecules, dust, and cloud particles) in the atmosphere, the energy is not blocked by atmospheric effects as energy at shorter wavelengths can be. In addition, since radar provides its own source of radiation, it is not dependent on solar energy being reflected by objects. This image was created by SAR technology available in 1995 and utilizing a single look angle.

Within the MASINT community, much work has been accomplished to automate analysis and comparison of sensor data. The results have produced processes that integrate wide area, low resolution spectral imaging sensors with narrow field-of-view, high-resolution spectral sensors to aid in detecting time sensitive and moving targets while also minimizing false detections.[106] The desire has been to let computers accomplish mundane, repetitive, time

[104] Sandia National Laboratories, "Synthetic Aperture Radar Imagery - Pentagon," http://www.sandia.gov/RADAR/images/pentagon.jpg (accessed September 27, 2007).

[105] Sandia National Laboratories, "Synthetic Aperture Radar Imagery - US Capital," http://www.sandia.gov/radar/images/ifs_cap.jpg (accessed September 27, 2007).

[106] Matthew Raymond Whiteley, “Non-Imaging Infrared Spectral Target Detection” (Masters Thesis, Air Force Institute of Technology, 1995). NASA’s Landsat program is a classic example of a multi-

consuming work that humans are not good at, and free the human element to make judgments and decisions that computers are not capable of doing. The issue is whether the human element can be aircrew, flying missions over hostile territory, or whether they have to be intelligence analysts sitting at a desk.

There are certainly applications for the information available from MASINT techniques and the following examples should help highlight a few more of them. While these may trend toward tactical applications, the willingness to empower aircrew to make decisions and the ability for aircrew to resource themselves with information could have operational and strategic implications in future conflicts.

Two-color multiview images, like the one shown in Figure 7, can indicate the impact results of a JDAM (Joint Direct Attack Munition) strike on munitions storage facility at night and through bad weather. This information would obviously be useful to aircrew trying to assess the need to conduct additional strikes on the facility or to retain weapons for additional targets.

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spectral sensor with low spatial resolution that has proven useful for highlighting scene changes. It has allowed higher-resolution sensors to be utilized more efficiently to gather data about the environment. Its eight-band, 30 meter resolution images, continues to be a valuable tool for indicating environmental changes, conducting shallow water bathymetry, and categorizing terrain even after decades of operation.

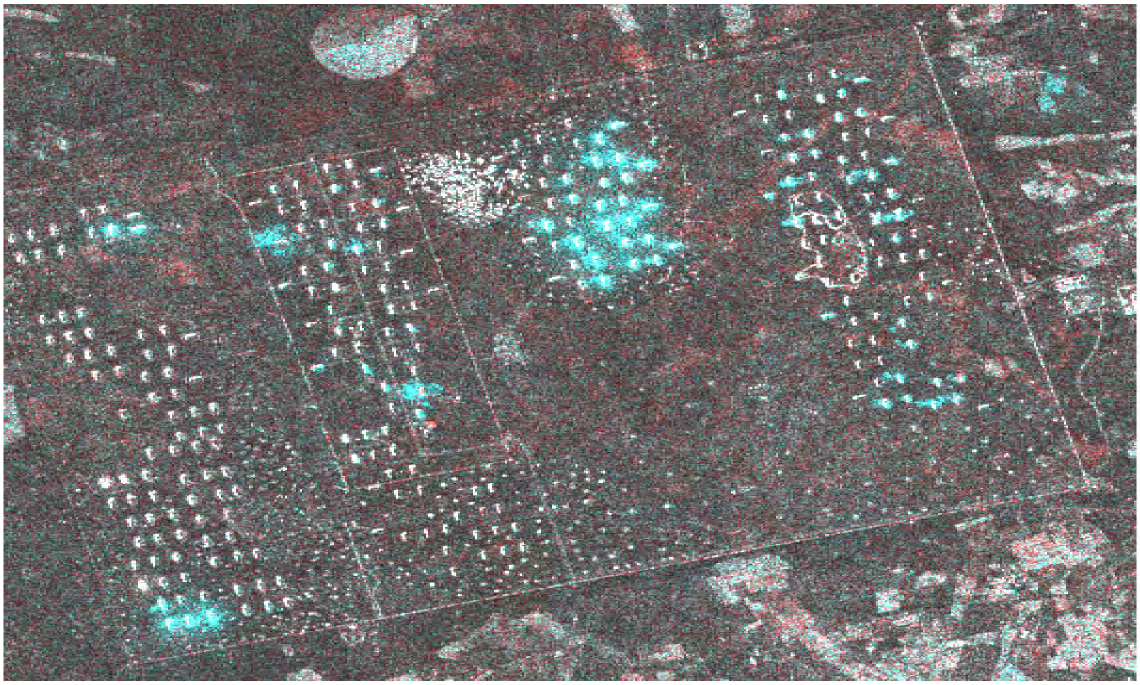

Figure 7. Battle Damage Assessment of Munitions Storage Facility[107]

The image above is the result of overlaying the product of change detection processing on a SAR image of a munitions storage facility. The areas highlighted by the light blue indicate areas where the radar reflectivity of the scene has changed since an earlier image was created. In this case, the changes are the result of battle damage from a military strike and provides intelligence and operations analysts the ability to assess which targets have been hit. The process could also be used to highlight new areas of construction at a facility. Change detection can be used with low-resolution imagery to highlight areas that warrant further investigation and the need for higher resolution but limited resources.

Coherent Change-Detection (CCD) images, such as depicted in Figure 8, could highlight vehicle tracks from subtle changes in surface radar reflectivity.[108] This type of information may be useful for indicating the hiding location of ballistic missile launchers, smuggling routes used by insurgents moving weapons across a border, or the tracks leading towards and from an insurgent weapons cache. In fact, CCD has even proven capable of detecting the ground settling that can result from some underground facilities and tunnels.

[107] Vexcel Corporation, "Vexcel Announces CCDMapT Coherent Change Detection Mapping System," http://www.vexcel.com/company/press/remote/ccdmap.html (accessed September 27, 2007).

[108] Sandia National Laboratories, "Synthetic Aperture Radar Applications," http://www.sandia.gov/radar/sarapps.html (accessed September 27, 2007).

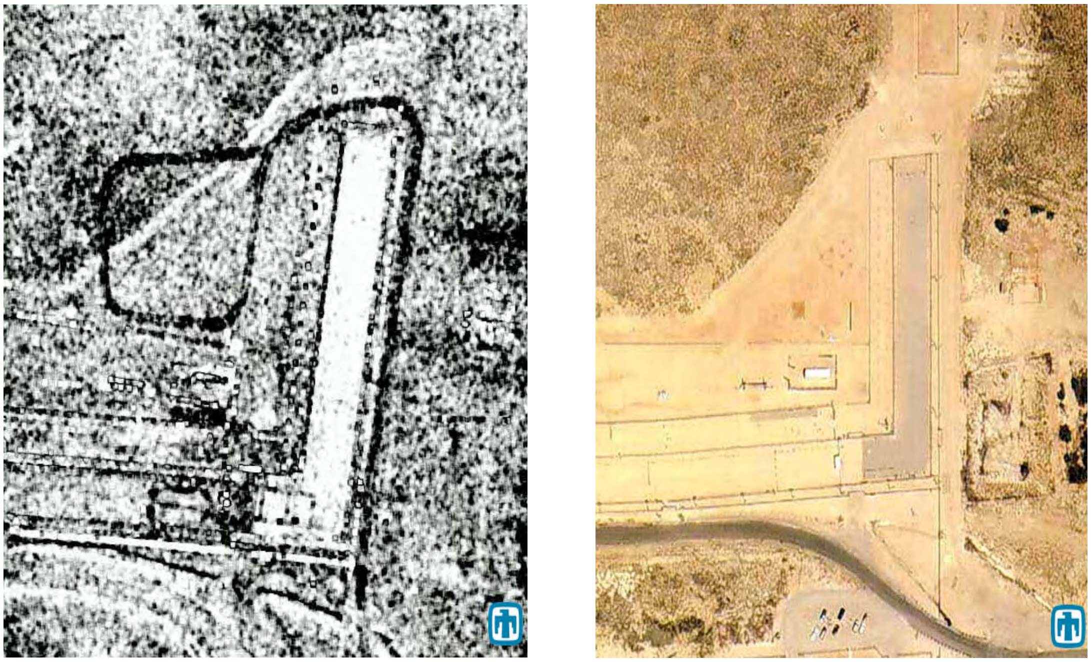

Figure 8. Coherent Change Detection of Vehicle Tracks[109]

Left: A SAR image, following Coherent Change Detection (CCD) processing, shows the path of a vehicle driven across an unpaved surface. CCD processing of SAR images utilizes SAR images, taken before and after a scene-changing event, to highlight areas of change. In this case, SAR images of the area are compared and processed to show the likely path of a vehicle driven through the scene. Right: An aerial photograph of the area imaged using SAR shows no perceivable indication of vehicle tracks.

Inverse SAR (I-SAR) techniques can point out rotating and moving targets to locate helicopters, air defense radars, or convoys, and similar to radar processing techniques, spectral change-detection algorithms can be employed to highlight areas where construction or the movement of vehicles and equipment may warrant additional attention.

Camouflage, Concealment, and Deception techniques, a different CCD, have become an increasing concern over the past decade.[110] As potential enemies procure and produce higher

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[109] Ibid.

[110] In addition to making targets difficult to locate, physical deception techniques can also complicate friend-or-foe decision-making. Over six times as many survey respondents indicated that they do not believe sensors currently onboard combat aircraft are sufficient for making these decisions. When

fidelity decoys, warfighters need access to tools that can help them identify potential targets and overcome the fog and friction of war. Many decoys can be countered with tactical IR detection and imaging systems such as LANTIRN, LITENING, and SNIPER targeting pods in combination with properly trained aircrew, but newer decoys promise to mimic thermal characteristics as well.

Hyperspectral imaging offers a tool to help counter CCD efforts and it is easy to anticipate using spectral signatures to assist in non-cooperative target recognition that could help prevent friendly fire and collateral damage. Similarly, advanced SAR image processing could be used to assess the radar reflective signature of a suspected target and automatically compare it to known data models for potential matches. The science behind MASINT holds many of the tools available to aid the warfighter, but only if the information can be placed within the reach of operators who must make decisions and employ weapons on the battlefield. Warfighters must be resourced with the ability to gather information and make decisions, so they can adapt to fluid environments.

An indication of the difficulty aircrews may face on the battlefield can be seen in Figure 9. It shows a real F-16 parked next to a decoy aircraft and fuel truck in the foreground. Without the aid of multi-band sensors from which to fuse a better picture of reality, resources could be expended destroying decoy targets. Not only does this spend valuable resources, but it could also produce a false sense of security if warfighters believe that threats have been eliminated.

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asked whether they believed that sensors expected in 2020 would be sufficient to make these decisions, the respondents indicated a shift towards agreeing, but over half of the responses indicated that they had no basis for an opinion. However, a third related survey question indicated that 91% believed that sensor capabilities onboard combat aircraft must be increased. Reference survey questions #26, #27, and #28. The results are graphically depicted in Appendix A, and the actual survey is depicted in Appendix B.

Figure 9. Decoy Military Targets[111]

Decoys are becoming increasingly realistic in their visual appearance and some manufacturers are marketing decoys that mimic the thermal properties of the items they are trying to emulate. This presents an increasingly difficult challenge to aircrew who must make time critical decisions on the battlefield. SAR and Spectral signature methods could provide warfighters with an increased ability to counter Camouflage, Concealment, and Deception techniques as well as provide another tool to help discriminate enemy from friendly forces and reduce friendly fire incidents during combat. In the image above, the real F-16 is the one in the background, whereas the near F-16 (SW on the tail) and the fuel truck "parked" in front of it are both decoys.

The SAR image of C-130s in Figure 10 clearly depicts the unique radar reflective characteristics of the aircraft. As decoys become more advanced, tactical aircraft will likely require sensors that enable aircrew to discern truth from fiction. Although realistic emissive and reflective signatures could be incorporated into decoys to defeat high-resolution imaging capabilities, the cost of buying decoys that accurately mirror physical, visual, thermal, spectral, and radar signatures may approach the cost of the object being modeled and make deception

[111] Aerostar International Inc., "Inflatable Military Decoys and Training Devices," http://www.aerostar.com/military/images/F-16_and_fuel_truck.jpg (accessed September 27, 2007).

efforts cost prohibitive. This is especially true if the U.S. transitions from a few traditional platforms, to a more diverse and distributed set of sensors that can be fused together.

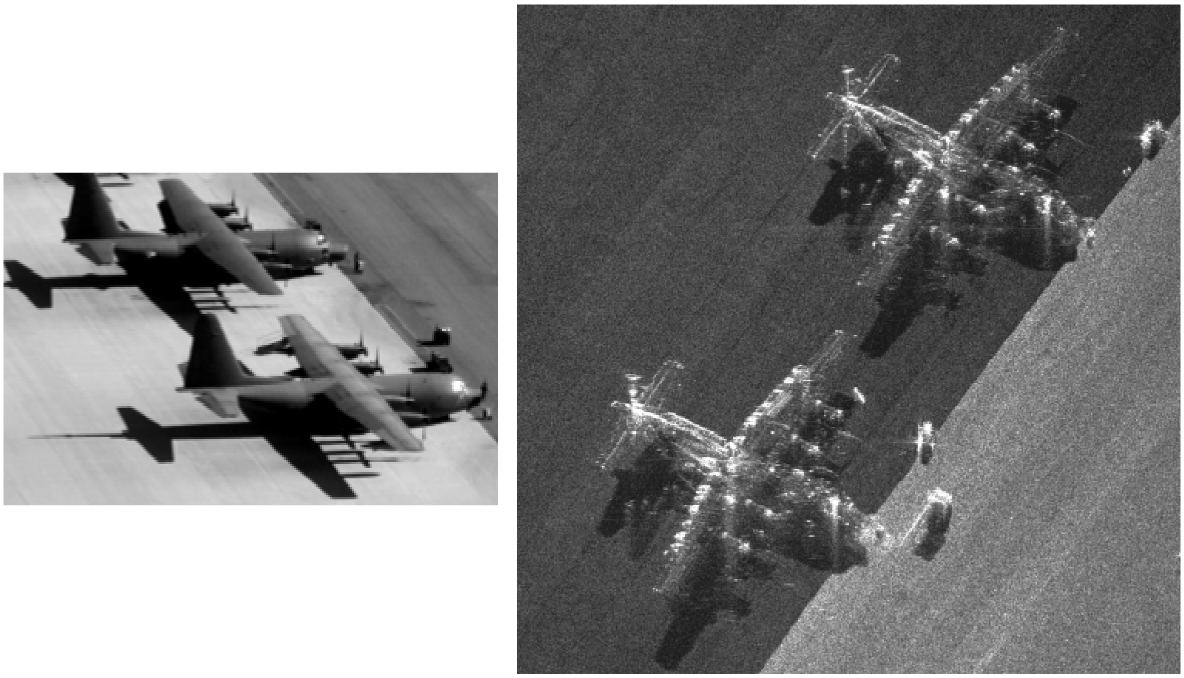

Figure 10. High Resolution SAR Target Recognition and Identification[112]

Left: A photograph of two C-130s (or are they decoys?). Right: A SAR image of the C-130s shown to the left. The combination of the visual spectrum (left hand picture) and the SAR image provides a stronger indication that these are actual C-130 aircraft, not decoys.

[112] A.W. Doerry et al., "A Portfolio of Fine Resolution Ka-Band SAR Images: Part I," Sandia National Laboratories, http://www.sandia.gov/radar/images/ka_band_portfolio.pdf (accessed September 27, 2007).

Conclusion

Initiative and creativity must be fostered by doctrine and individuals must be resourced with the ability to gather the information needed to make decisions. While every platform should be network capable, it is paramount that a degree of independence is maintained to guarantee a degree of resiliency. Resiliency may not be "cost efficient," but it is a risk mitigation technique. It guards against a single critical failure that could shut down Kometer's Combat Air Operations System. Increasing tactical sensor capabilities will never eliminate the "fog" of war, but increased availability of information can reduce it. Stovepipes must decay, and more integrated training must occur to reduce "friction" in war and allow the friendly "OODA Loop" to spin more freely.

Non-Traditional ISR must become more traditional, and traditional ISR technologies must be explored for potential application on more distributed and tactical platforms to synthesize a larger aperture for the intelligence collection system. If the U.S. expects to maintain a measure of military superiority in the future, it must face the fact that adversaries are not likely to confront U.S strengths in a head-on clash of wills – deception and asymmetric threats that challenge or target information superiority are much more likely. The U.S. military must continue to transform. It must be a nimble and adaptive force to cope with an increasingly complex and adaptive world.

Doctrine embodies the core concepts that describe how the U.S. military believes it should operate. It must be clear and consistent to prevent confusion and it must remain adaptive as the environment changes. Joint doctrine should set the standard and not simply be the result of merging individual service doctrine together in committee – diluting "best practices" into best compromises. It must clearly and logically define terms like "command," "control," and "command-and-control." It should be concise, and leave lengthy discussions of tactics, techniques, and procedures to separate documents that can change more freely. With increasing emphasis on joint operations, one must question the relevancy of service specific doctrine – they

too often conflict or confuse the concepts of joint doctrine. If services feel compelled to provide additional service specific amplifying information, then they should publish supplements instead of independent doctrine.

In combat, the effects of multiple efforts must be massed in a unified manner to meet political objectives, while leaving the details of mission execution to the experts who will carry out “mission-type” orders. “Centralized Command and Decentralized Control of Distributed Operations” seems to be what the future demands. It is time for the Air Force to let go of the tenet of centralized control. It carries too much unintended baggage in the joint community and simply does not adequately convey the Air Force’s nonnegotiable demand for an airman in “command” of air operations. The Air Force must continue to ensure the efficacy of information superiority. It must continue to break down divides between Intelligence and Operations, and it must recognize the continued need to resource warfighters with information and the tools to enable decision-making in a communications denied environment.

The limited availability and predictability of ISR platforms led the U.S. military to adopt concepts such as NTISR to fill ISR gaps, and the appetite for information is not expected to decrease. NTISR was initially intended to capitalize on the ability to collect information from distributed systems, such as fighter aircraft flying with advanced targeting pods on board.[113] However, the natural and continuing evolution of NTISR should be to empower aircrews to act within a centralized command structure, guided by ROE, which encourages initiative through decentralized control to conduct distributed operations without constraining oversight from higher headquarters.

Decentralized execution is encouraged by decentralized control. The combination of centralized command, decentralized control, and MASINT enabled distributed operations is an

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[113] Ronald F. Sams, *Air Force Fiscal Year 2005 ISR Programs. U.S. Senate Armed Services Committee Testimony* (Washington DC: United States Senate, 2005).

effective way for the U.S. to keep an opponent on the defensive and to operate inside of the enemy's Observe-Orient-Decide-Act (OODA) Loop.[114] The speed of execution and decision-making will remain a key metric in the future of warfare. While bandwidth improvements will increase the ability to move more data to and from centralized command structures, it also makes communications a critical node for U.S. enemies to target — and may prove an Achilles' heel if warfighters are not empowered with the resources, sensors, authority, and training to make decisions in real time on the battlefield.

Continuing education and awareness are the first steps towards improving integration of air, space, and cyberspace within the Air Force and with the other services. Better functional integration within the Air Force will allow it to more effectively contribute to the realm of joint operations, and permit the U.S. military to finally train in the same manner that it would like to fight. More ISR products need to be integrated into daily training and warfighting exercises, they need to be placed on networks accessible by the warfighter, and they need to be presented in more standardized formats that do not require the warfighter to figure out how to navigate every intelligence organization's website. The warfighter does not need to know the "hows and whys" that often place intelligence products above the secret level, but they need to have access to the actionable products that the ISR community produces. Getting information into the right hands at the right time is an essential step toward allowing users to develop accurate perceptions of current technical capabilities and to help create stable requirements for future acquisitions programs.

Pursuing the objective of making ISR a product of all air and space platforms will undoubtedly mean that some new acquisition efforts will be undertaken. A significant factor in determining the success of acquisition programs has traditionally been the ability to define clear requirements for program managers, system engineers, and designers that meet the needs and

[114] Carl Baner, "Defining Aerospace Power," http://www.airpower.maxwell.af.mil/airchronicles/cc/baner.html (accessed September 27, 2007).

desires of the warfighter. The problem with requirements is that those who develop them often do not understand the art of the possible. The result is a frustratingly long iterative process that increases costs and takes valuable time. The warfighter must be an integral part of the process, so advanced technology can be more rapidly transitioned to, and accepted by, the warfighter. The better-educated and familiar airmen are with advanced sensors technologies, the more likely they are to be able to help develop reasonable sensor requirements early in the process. Likewise, it increases the probability that these new capabilities will be embraced – not resisted – by the warfighter when they are fielded.

Awareness and knowledge led to the acquisition of IR targeting pods on combat aircraft and vehicles. Similarly, MASINT techniques such as spectral and advanced SAR imaging techniques need to be pursued for more than just traditional ISR applications. NTISR blurs the lines between ISR and airpower application, but so do armed Predator aircraft. This blurring reemphasizes the importance of integrated training and exercises to continue to tear down stove-piped thinking and the need to field advanced sensors on tactical aircraft. Decision-quality information needs to be placed in the hands of airmen that are empowered to observe, orient, decide, and act within well-defined rules to successfully fulfill the Air Force mission of providing sovereign options that fulfill a joint force commander’s intent and meet national objectives.

APPENDIX A

Survey Background and Results

A survey of Air Force officers was conducted as part of the research for this paper. The intent of the survey was to assess the level of familiarity with MASINT, the desirability for advanced sensor capabilities on tactical airborne platforms, and the perceptions of Air Force officers regarding intelligence integration and the appropriate level of control for combat air operations.

The target audience for this survey was mid-career officers with a high likelihood of completing at least a 20-year career in the Air Force. In order to limit the impact of this survey on current operations and to help focus the survey towards the desired population, the survey was distributed to personnel in non-operational assignments, although many had extensive operational experience and some were assigned to Operational Test and Evaluation (OT&E) units with an active flying mission. Most participants were in a student status, attending Intermediate Developmental Education (IDE), the School of Advanced Air and Space Studies (SAASS), or the School of Advanced Military Studies (SAMS). However, respondents also included aircrew from the 53d Test and Evaluation Group (TEG). The 53d TEG was included because it guaranteed a high probability of soliciting responses from operationally experienced aircrews that are familiar with integrating and testing new sensor capabilities. The 53d TEG is unique because it comprises highly experienced aircrews from most of the Air Force's major weapon systems (MWS) – each is at least qualified as an instructor in their crew position, and approximately half are graduates from the USAF Weapons School (USAFWS). The following list describes more specifically the population groups that participated in this survey.

1. Air Command and Staff College (ACSC) students
2. Air Force Institute of Technology (AFIT) IDE students
3. Command and General Staff College (CGSC) IDE students
4. School of Advanced Air & Space Studies (SAASS) students
5. School of Advanced Military Studies (SAMS) students
6. 53d Test and Evaluation Group (53d TEG) aircrews

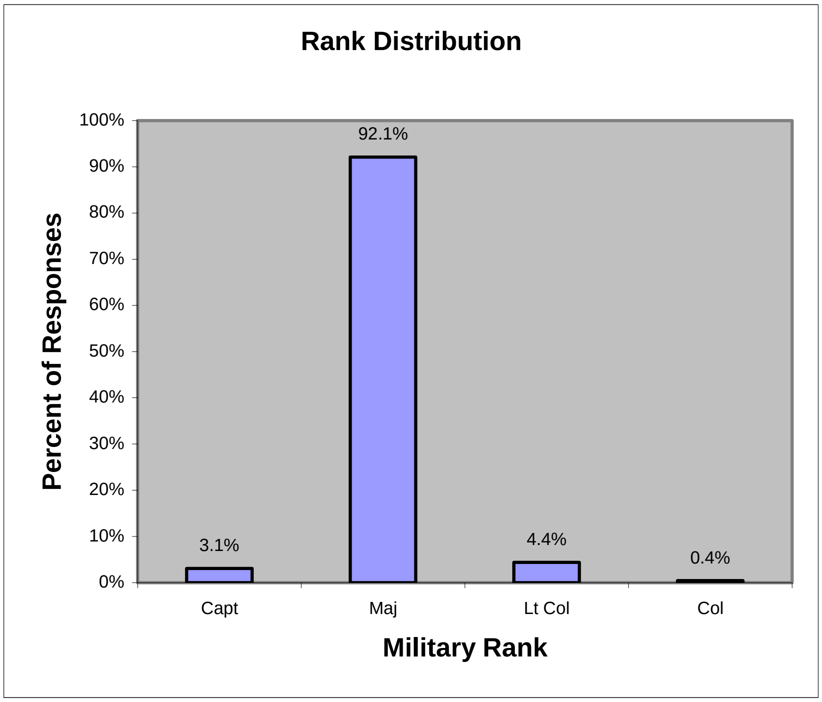
The survey was coordinated with the commanders of each population group and survey control numbers were obtained from the Air Force Manpower Agency (AFMA), Air Education and Training Command (AETC), and the Army Command and General Staff College (CGSC). The survey was administered using an internet based application and delivered via e-mail to the participants. E-mails were sent directly to participants who were in a student status, and routed through the unit commanders within the 53d TEG to limit the impact on their test mission. As a result, the total number of surveys distributed in the 53d TEG is unknown and the response rate is not available. The response rate from AFIT students was noticeably lower than other student groups, but a 51% response rate was still considered a good result. AFIT has been experiencing difficulties with its e-mail server and it is common for messages to be inadvertently blocked.[115]

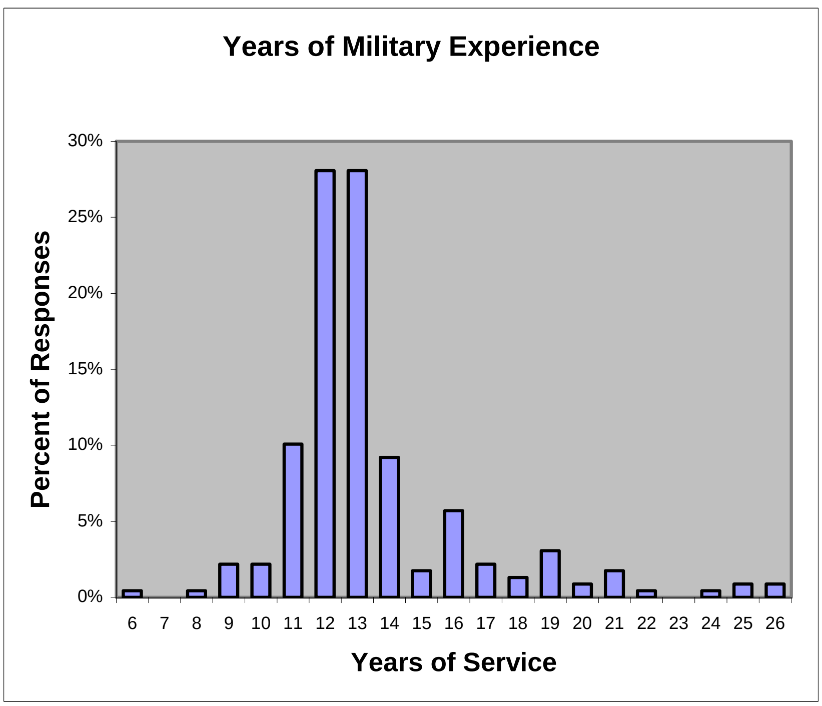
A total of 231 responses were received. The data from three of the respondents was removed based on a preliminary review and quality control assessment of the data. One was removed because the respondent did not answer any of the questions, another two were removed because the respondents indicated that they were not Air Force officers and failed to provide any amplifying information to determine if their participation was appropriate. The following table indicates the distribution of response rates for the remaining 228 completed surveys.

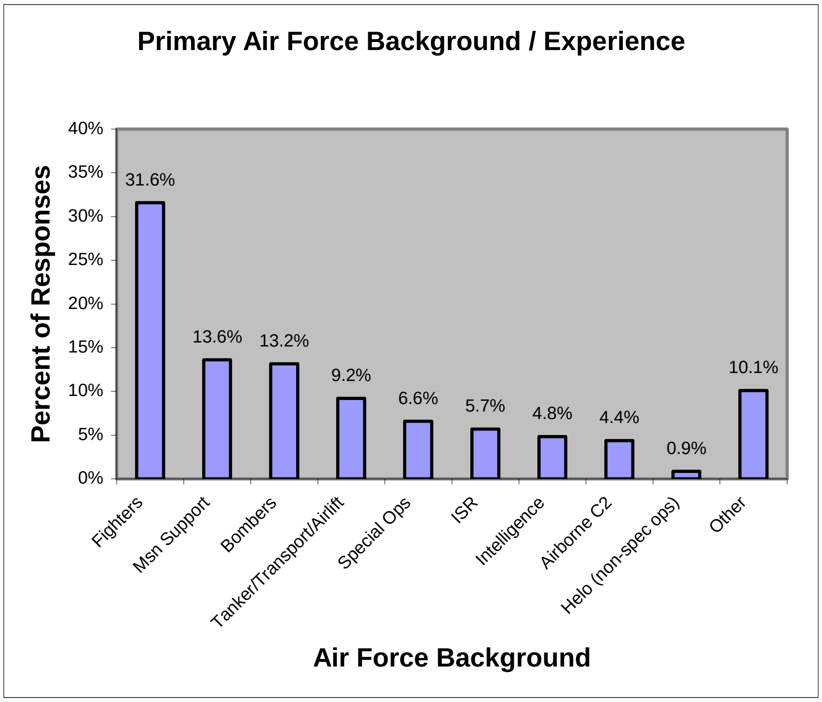
[115] The author has personally experienced AFIT's e-mail problems and personal conversations with personnel assigned to AFIT during the period of the survey confirmed that the problems still exist.

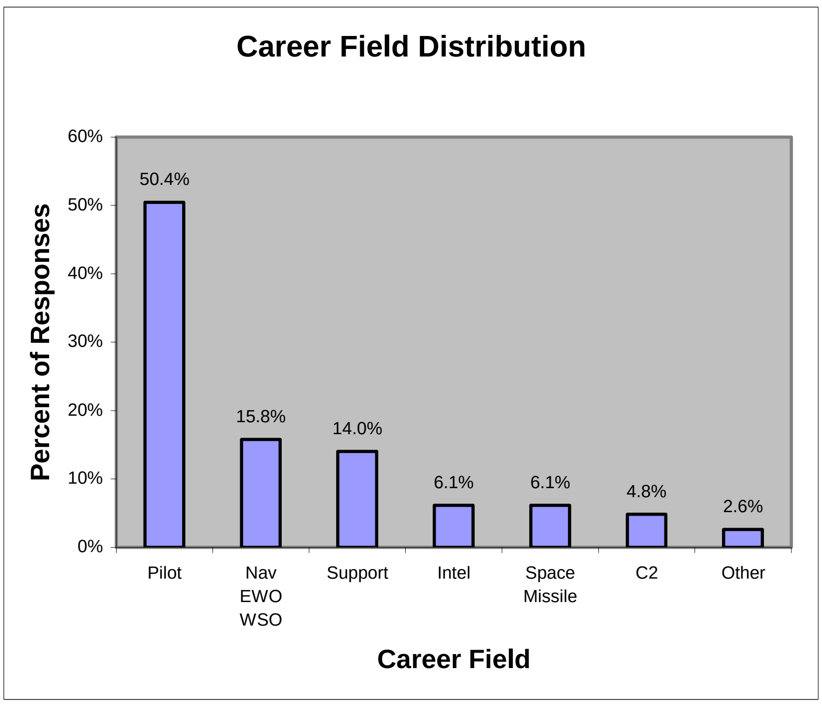
Organization	**Survey Responses**	**Surveys Distributed**	**Response Rate**
ACSC	88	138	63.8%
AFIT	30	59	50.8%
CGSC	51	80	63.8%
SAASS / SAMS	32	48	66.7%
53d TEG	27	-------	-------
Total	**228**	**> 352**	**Approx 62%**

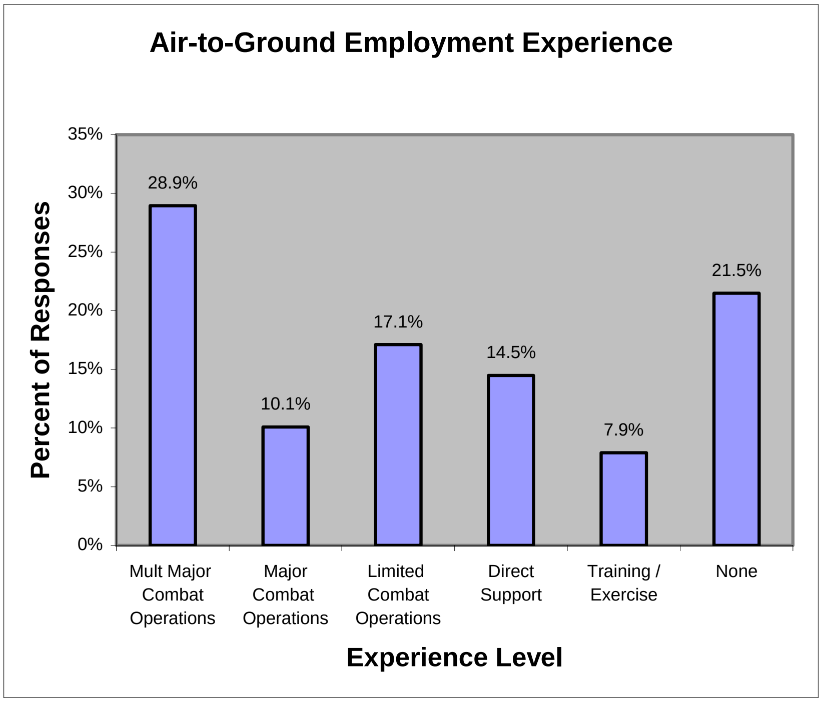
The survey consisted of 37 questions as well as a place for participants to leave comments at the end. The first eight questions were designed to capture demographic information. Most of the questions were designed to use a multiple-choice format – a single question requested respondents to provide their primary Air Force Specialty Code (AFSC). Some demographic questions requested amplifying information if the respondent did not fit into one of the provided grouping categories, while the remaining survey questions were multiple-choice and the majority requested the participant to provide their opinion on a Likert scale. The collection of demographic information was intended to help determine if the survey reached the desired audience and help eliminate inappropriate respondents – as previously indicated, three respondents' data were removed. Additionally, there was a desire to determine if responses were statistically different between participants experienced with employing air power and other participants. Analysis of the demographic results confirmed that the audience consisted of a breadth of Air Force career fields and consisted mostly of mid-career officers. The results also indicate that there was no significant difference in responses based upon career fields or combat experience; therefore, the data was aggregated to increase the sample size and increase the confidence that the data represents the perceptions of the mid-level career officers within the entire the Air Force. The following graphs summarize the demographics of the respondents:


Rank Distribution
Percent of Responses
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
92.1%
3.1%
4.4%
0.4%
Capt
Maj
Lt Col
Col
Military Rank


Years of Military Experience
Percent of Responses
30%
25%
20%
15%
10%
5%
0%
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Years of Service


Primary Air Force Background / Experience
Percent of Responses
40%
35%
30%
25%
20%
15%
10%
5%
0%
31.6%
13.6%
13.2%
9.2%
6.6%
5.7%
4.8%
4.4%
0.9%
10.1%
Fighters
Msn Support
Bombers
Tanker/Transport/Airlift
Special Ops
ISR
Intelligence
Airborne C2
Helo (non-spec ops)
Other
Air Force Background

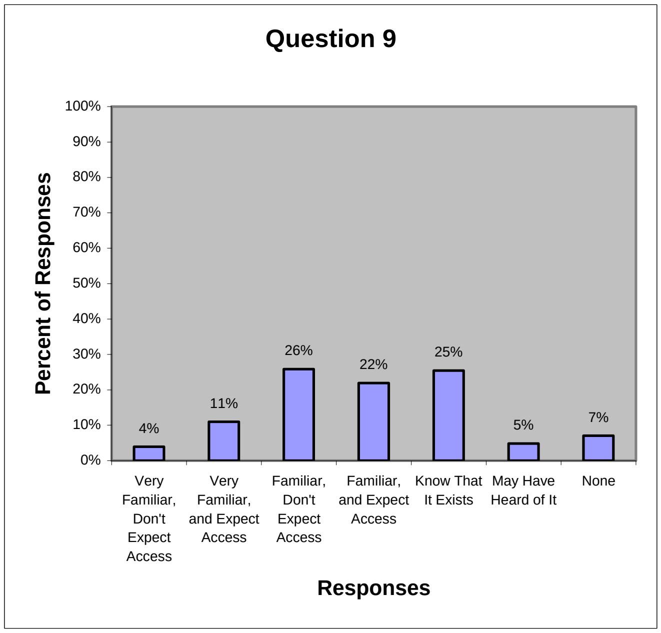

Career Field Distribution
Percent of Responses
60%
50%
40%
30%
20%
10%
0%
50.4%
15.8%
14.0%
6.1%
6.1%
4.8%
2.6%
Pilot
Nav
EWO
WSO
Support
Intel
Space
Missile
C2
Other
Career Field



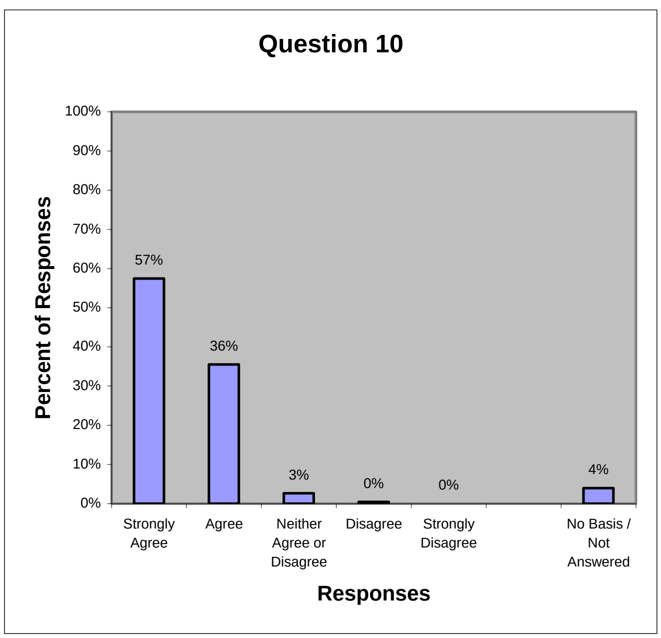
The remainder of this appendix includes the non-demographic questions and graphs depicting the survey results. It should be noted that, unlike most Likert scale surveys, this survey gave respondents an additional option for each question: "no basis for an opinion." This option was added to prevent the data from becoming skewed by participants who might otherwise have chosen "neither agree or disagree" as their response and to indicate more clearly the level of agreement amongst participants who assessed themselves capable of answering the survey questions. A significant number of respondents chose "no basis for an opinion," while only approximately 0.1% of the questions were not answered. Thus, in the graphical depiction of the responses, "no basis for an opinion" and unanswered questions are combined because it is assumed that unanswered questions were the result of respondents having no basis for an opinion.

The following is a list of the non-demographic questions and the corresponding graphical depiction of the responses. Images of the web-based survey are included in Appendix B.

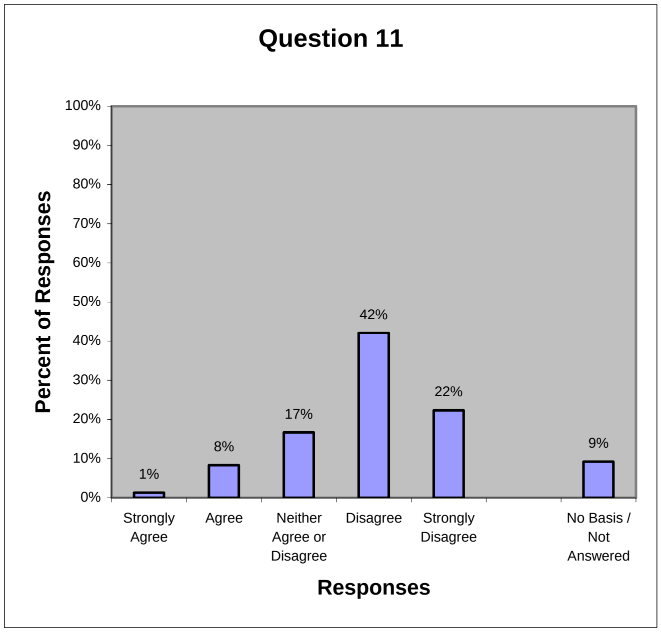
Question 9) How familiar are you with Measurement and Signature Intelligence (MASINT)?



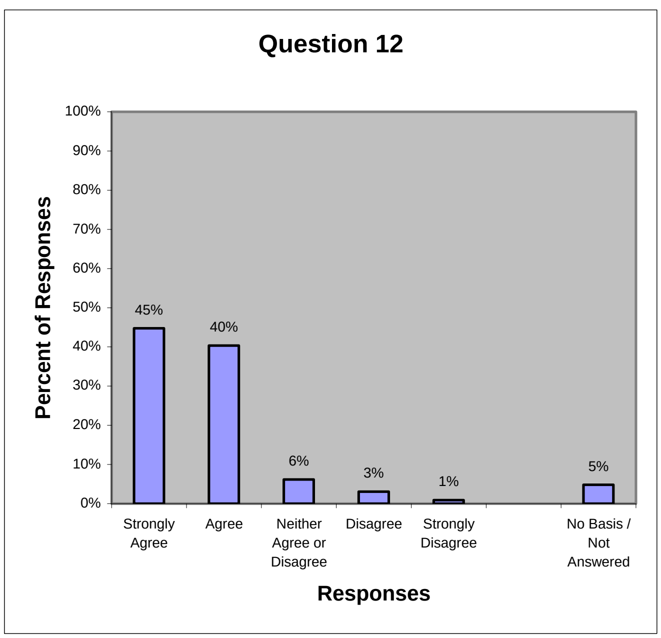
Question 10) Dynamic Targeting (DT) / Time Sensitive Targeting (TST) / Time Critical Targeting (TCT) is a growing trend in air operations. (Considered DT, TST, and TCT as a single category)



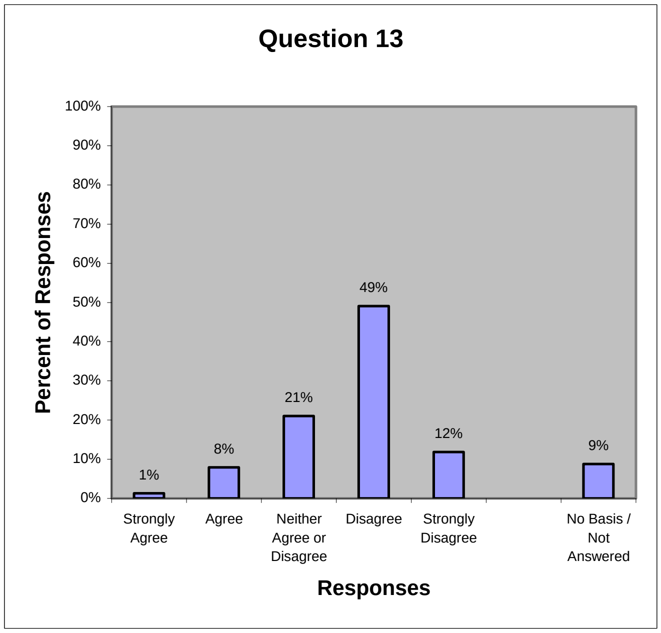
Question 11) Non-Traditional ISR was a planned capability envisioned when current sensors were designed for "Shooter" platforms.



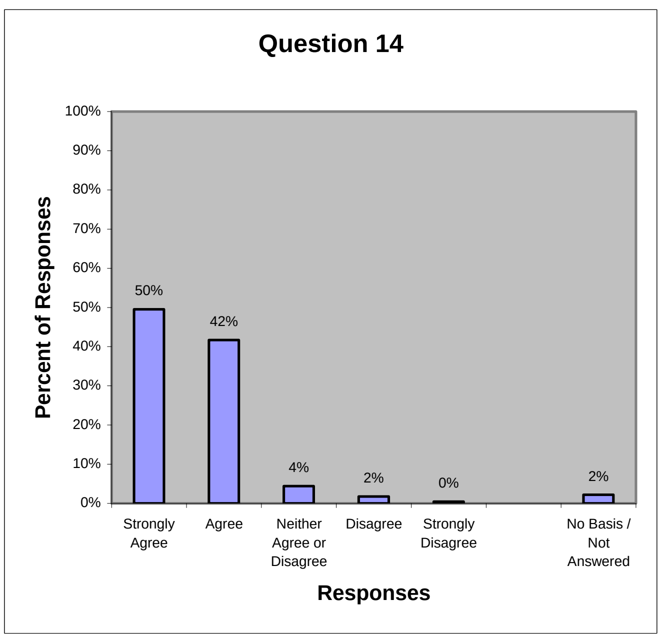
Question 12) New sensors developed for "Shooter" platforms should be designed to integrate better into the overall intelligence collection effort.



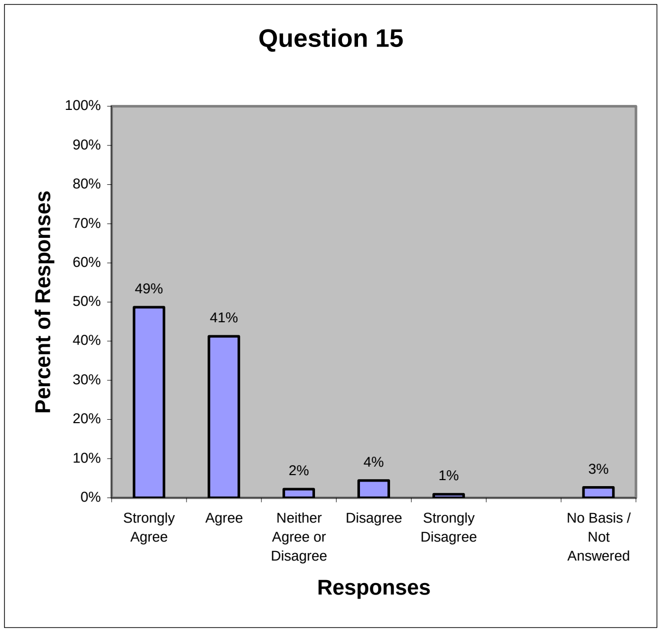
Question 13) Non-Traditional ISR is a well integrated part of the intelligence collection effort.



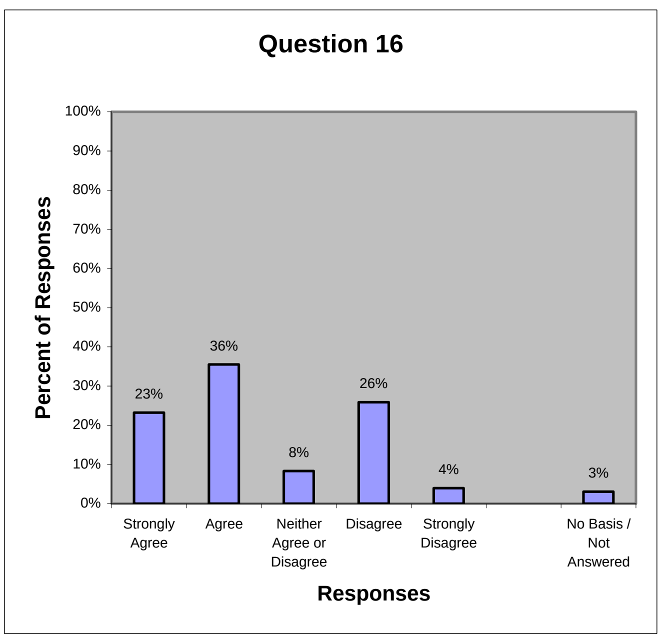
Question 14) Future adversaries are likely to target U.S. communications / reach-back capabilities to reduce effectiveness of air operations.



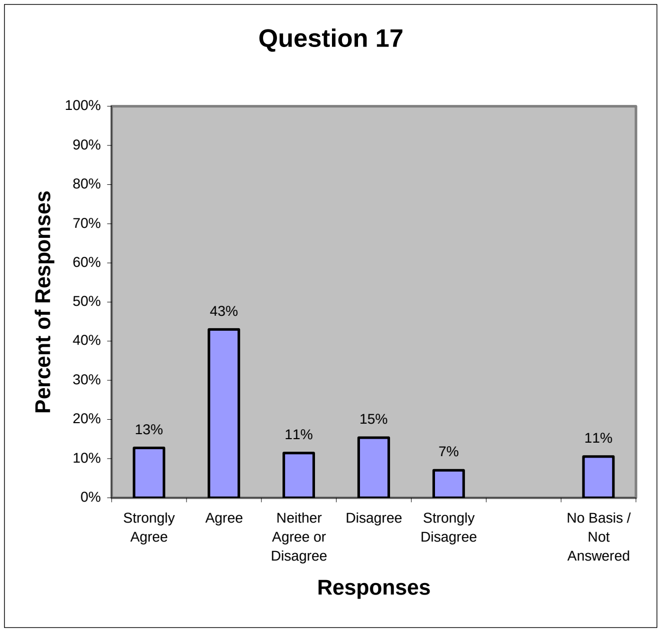
Question 15) Airborne manned traditional ISR assets are expected to remain Low Density / High Demand.



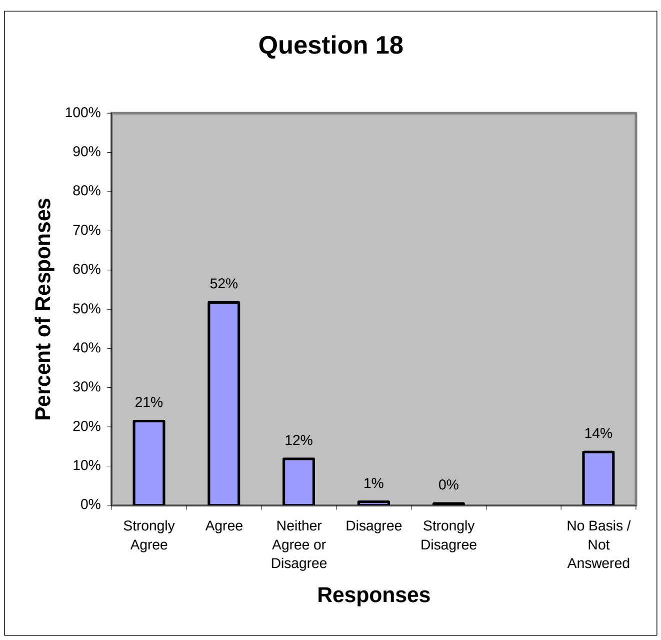
Question 16) Airborne unmanned traditional ISR assets are expected to remain Low Density / High Demand.



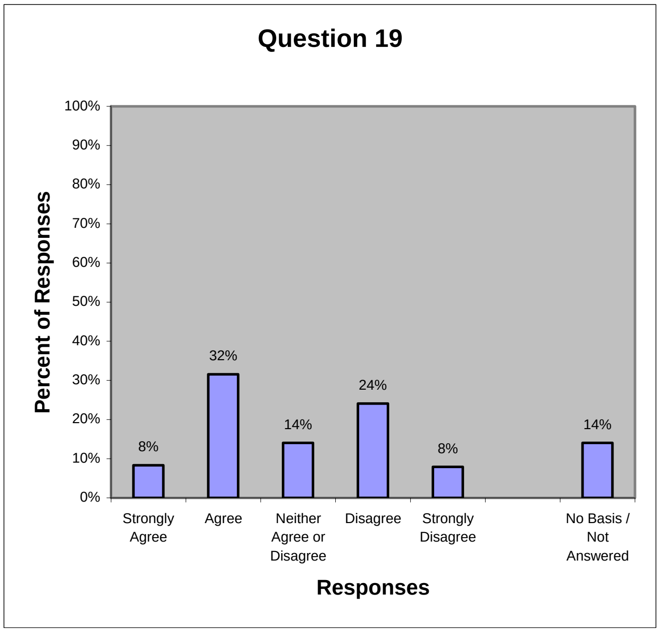
Question 17) I am familiar with sensor technologies capable of highlighting scene changes from previous sensor passes / missions / etc.



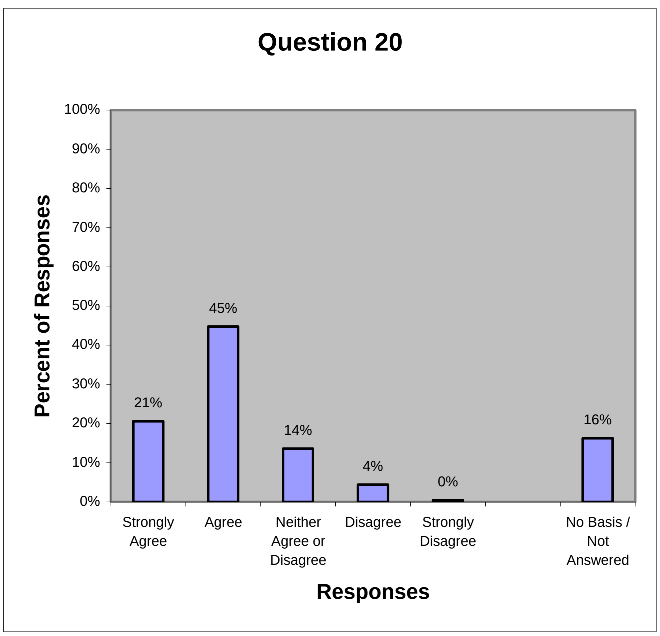
Question 18) Sensor technologies capable of displaying scene changes from previous sensor passes / missions / etc. would be useful to aircrew performing the "shooter" mission against ground targets.



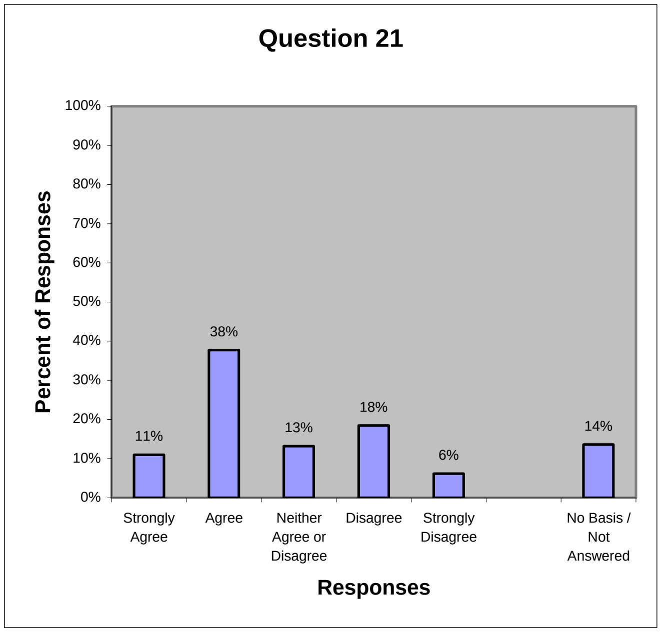
Question 19) I am familiar with sensor technologies capable of indicating the material composition of ground targets. (Ex. Type of Material / Paint / Chemical Emissions / etc.)



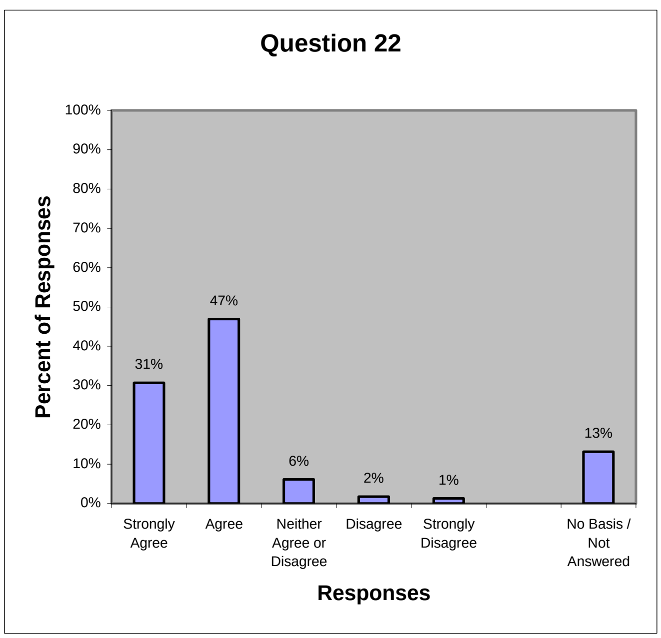
Question 20) Sensor technologies capable of indicating the material composition of ground targets would be useful to aircrew performing the "shooter" mission against ground targets. (Ex. Type of Material / Paint / Chemical Emissions / etc.)



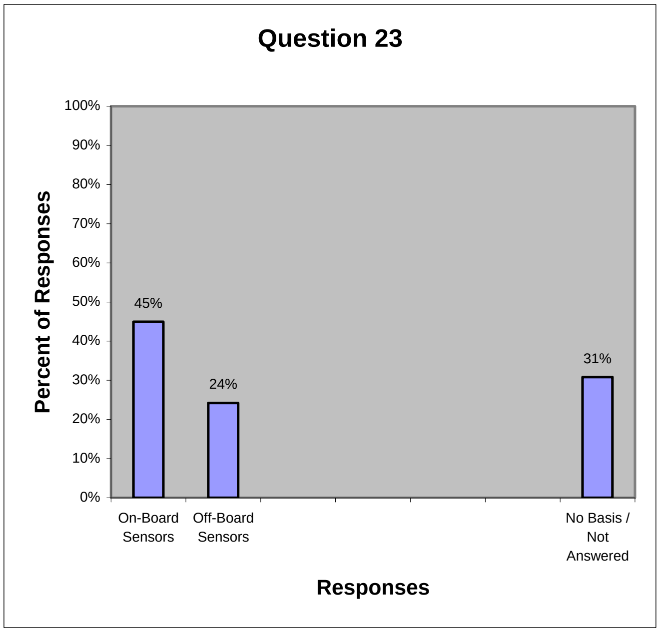
Question 21) I am familiar with sensor technologies capable of building a 3-Dimensional representation of a scene / target.



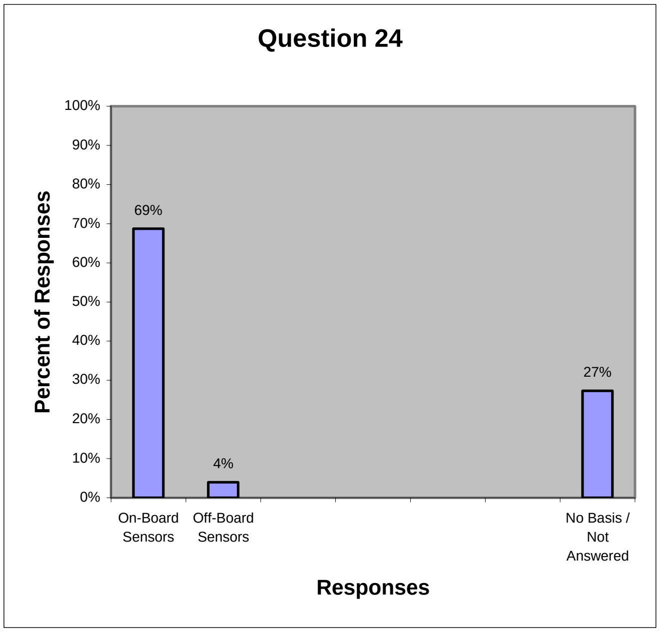
Question 22) Sensor technologies capable of building a 3-Dimensional representation of a scene / target would be useful in performing the "shooter" mission against ground targets.



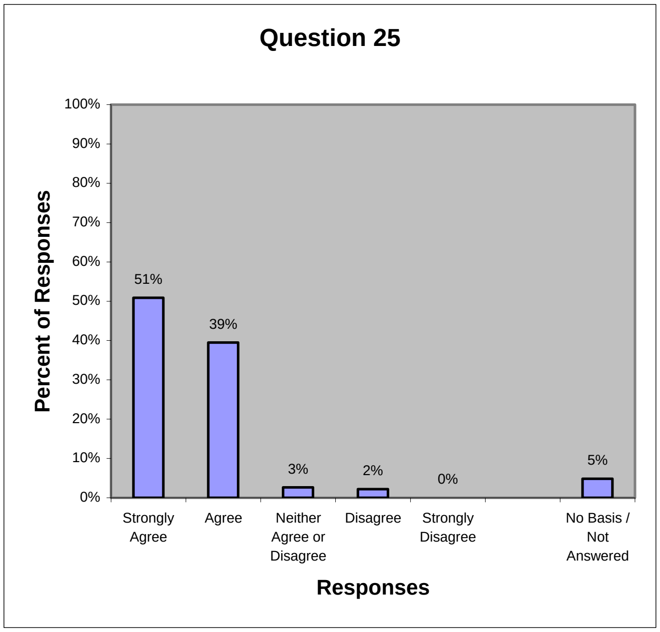
Question 23) In Dynamic Environments, aircrew prefer to make targeting decisions based upon information from:



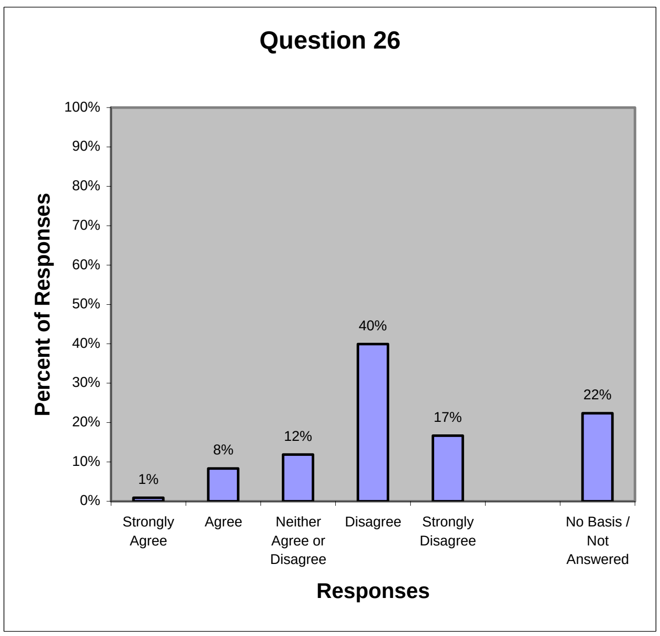
Question 24) In Non-Dynamic Environments, aircrew prefer to make targeting decisions based upon information from:



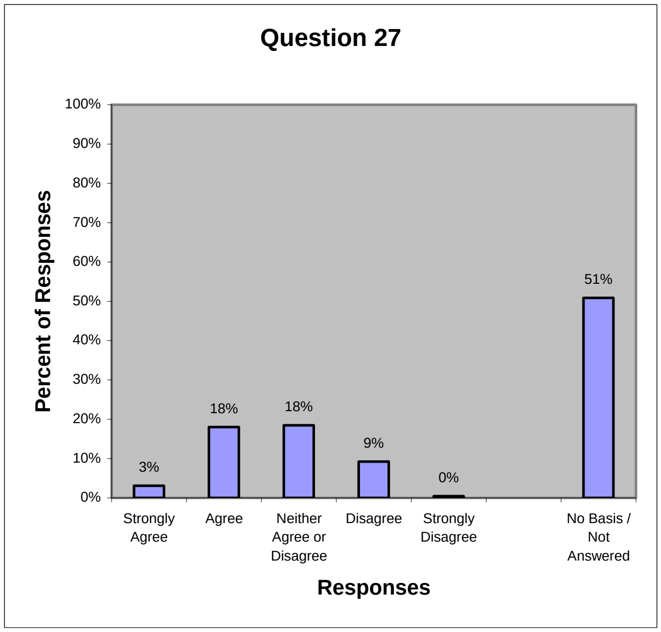
Question 25) Future threats are likely to increase the use of deception techniques (camouflage / concealment / decoys) to disrupt ground-targeting efforts.



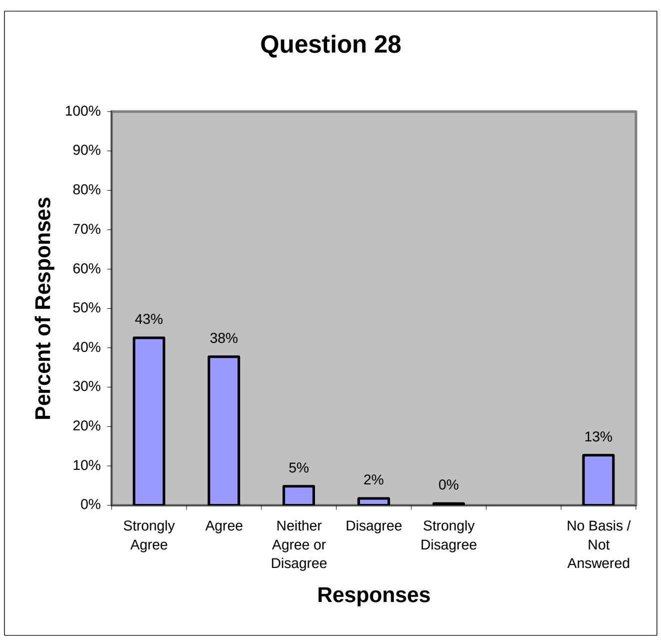
Question 26) Sensors available today onboard "Shooter" platforms are sufficient for making friend / foe decisions in threat environments that include physical deception techniques (camouflage / concealment / decoys) of ground targets.



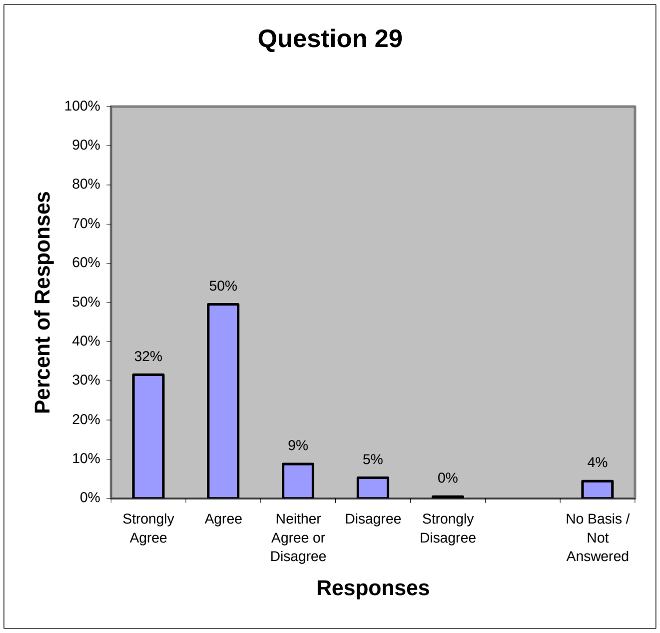
Question 27) Sensors expected in 2020 onboard "Shooter" platforms are sufficient for making friend / foe decisions in threat environments that include physical deception techniques (camouflage / concealment / decoys) of ground targets.



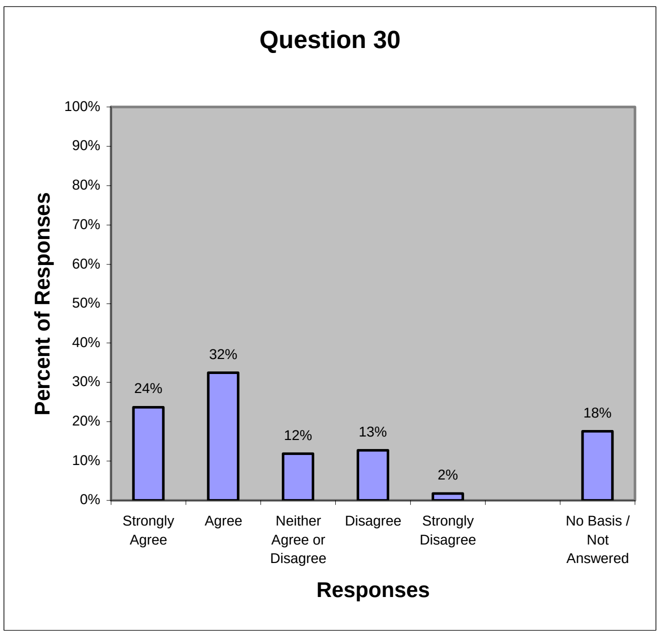
Question 28) Increasing sensor capabilities on-board "shooter" platforms is necessary in order to meet adversarial challenges of the future.



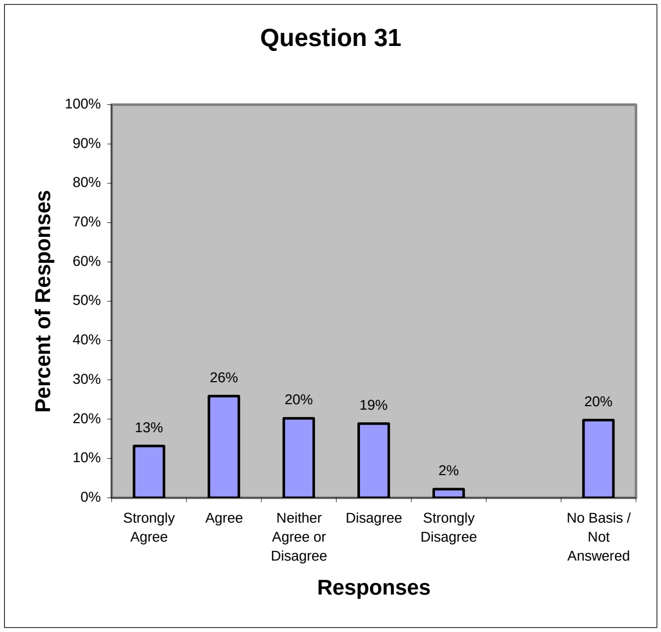
Question 29) Decision-Making should rest at the level with greatest Situational Understanding.



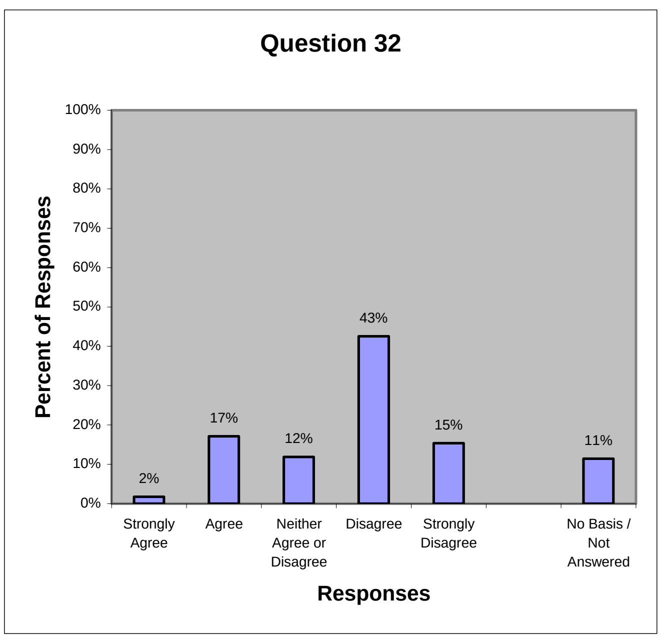
Question 30) Decision-Making in Low Intensity combat air operations is currently Over-Centralized.



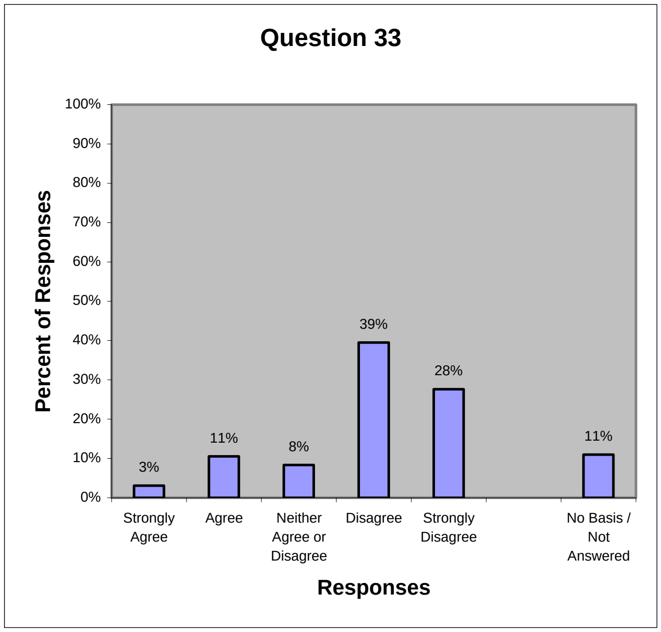
Question 31) Decision-Making in High Intensity combat air operations is currently Over-Centralized.



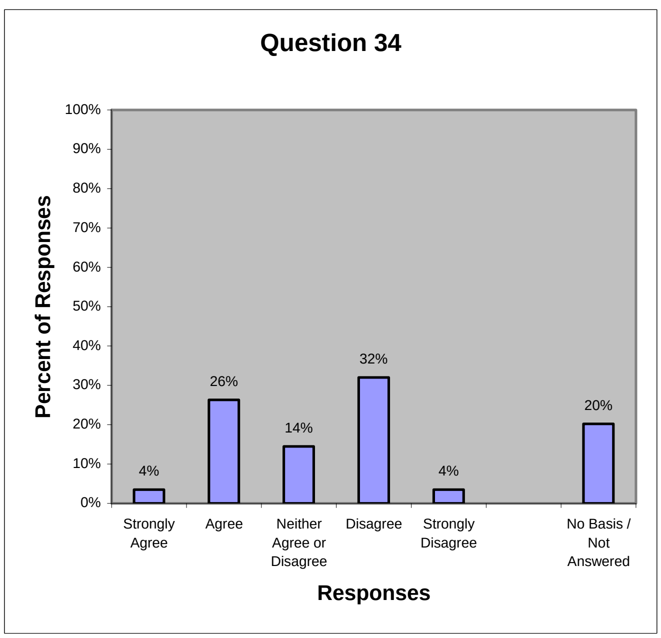
Question 32) Decision-Making in Low Intensity combat air operations should be Centralized as much as technologically feasible.



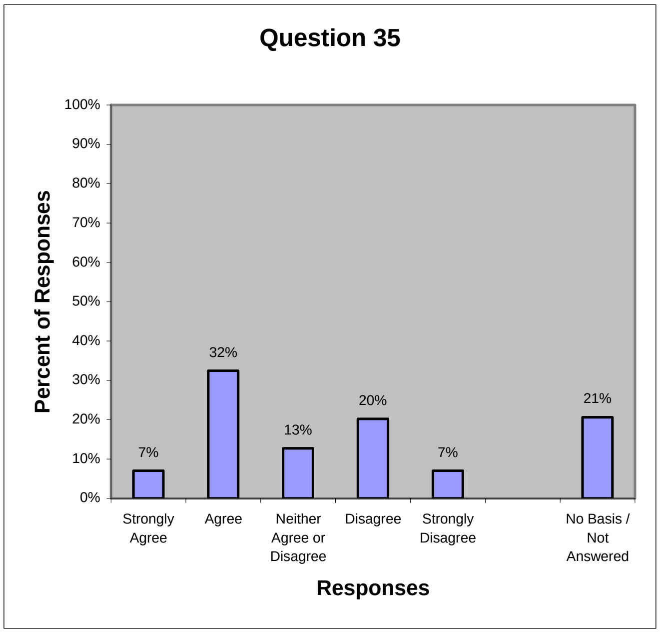
Question 33) Decision-Making in High Intensity combat air operations should be Centralized as much as technologically feasible.



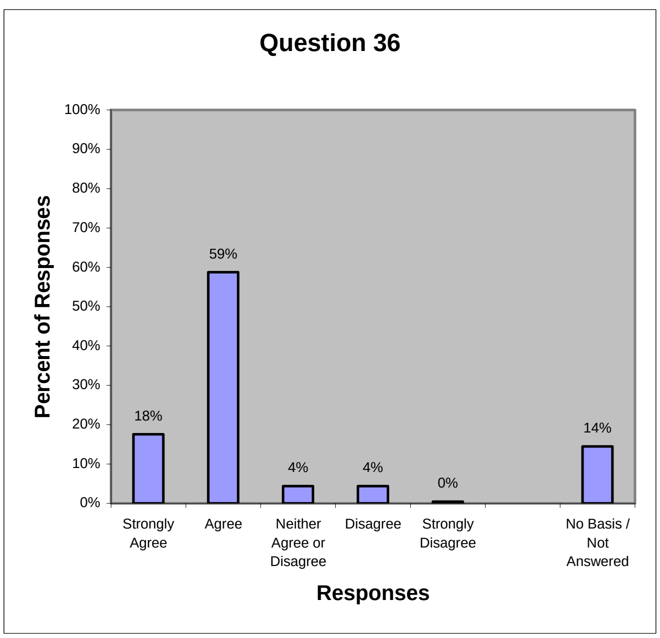
Question 34) Sufficient efforts are made to make ISR products accessible to aircrews.



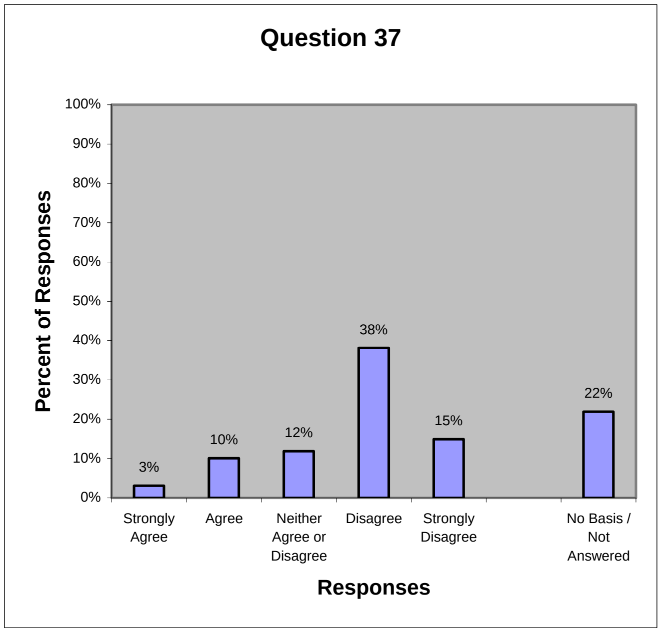
Question 35) Aircrews have sufficient security clearances to access ISR products.



Question 36) Secret Level networks, such as the Secret Internet Protocol Router Network (SIPRNet), are commonly accessible during combat mission planning.



Question 37) Top-Secret Level networks, such as the Joint Worldwide Intelligence Communication System (JWICS), are commonly accessible during combat mission planning.



APPENDIX B

Web Based Survey

Survey Control Numbers:
USAF: SCN 07-69, valid through 1 March 2008
Air University: SCN 07-018, valid through 23 Oct 2008
US Army Command and General Staff College Quality Assurance: 07-032

Approval Coordination:
Air Command and Staff College (ACSC)
Command and General Staff School (CGSS)
School of Advanced Air & Space Studies (SAASS)
School of Advanced Military Studies (SAMS)
Air Force Institute of Technology (AFIT)
53d Test and Evaluation Group (53 TEG)

Purpose of Survey: Your participation in this survey is requested in order to support research being conducted to answer questions regarding the desirability for advanced sensor capabilities on tactical airborne platforms. Information collected will also be used to analyze the advantages and disadvantages of a force equipped with capabilities that enable centralized verses decentralized decision-making in future air operation.

This survey should take approximately 10-15 minutes to complete.
There is an opportunity to provide additional information or comments at the end.

Participation in this survey is strictly voluntary, but greatly appreciated.

Your individual responses to the survey questions will be kept confidential.

Thank you for your time and assistance in completing this survey.

Major Mark E. Blomme, USAF
School of Advanced Military Studies
AFELM/CGSC, Ft Leavenworth KS
mark.blomme@us.af.mil

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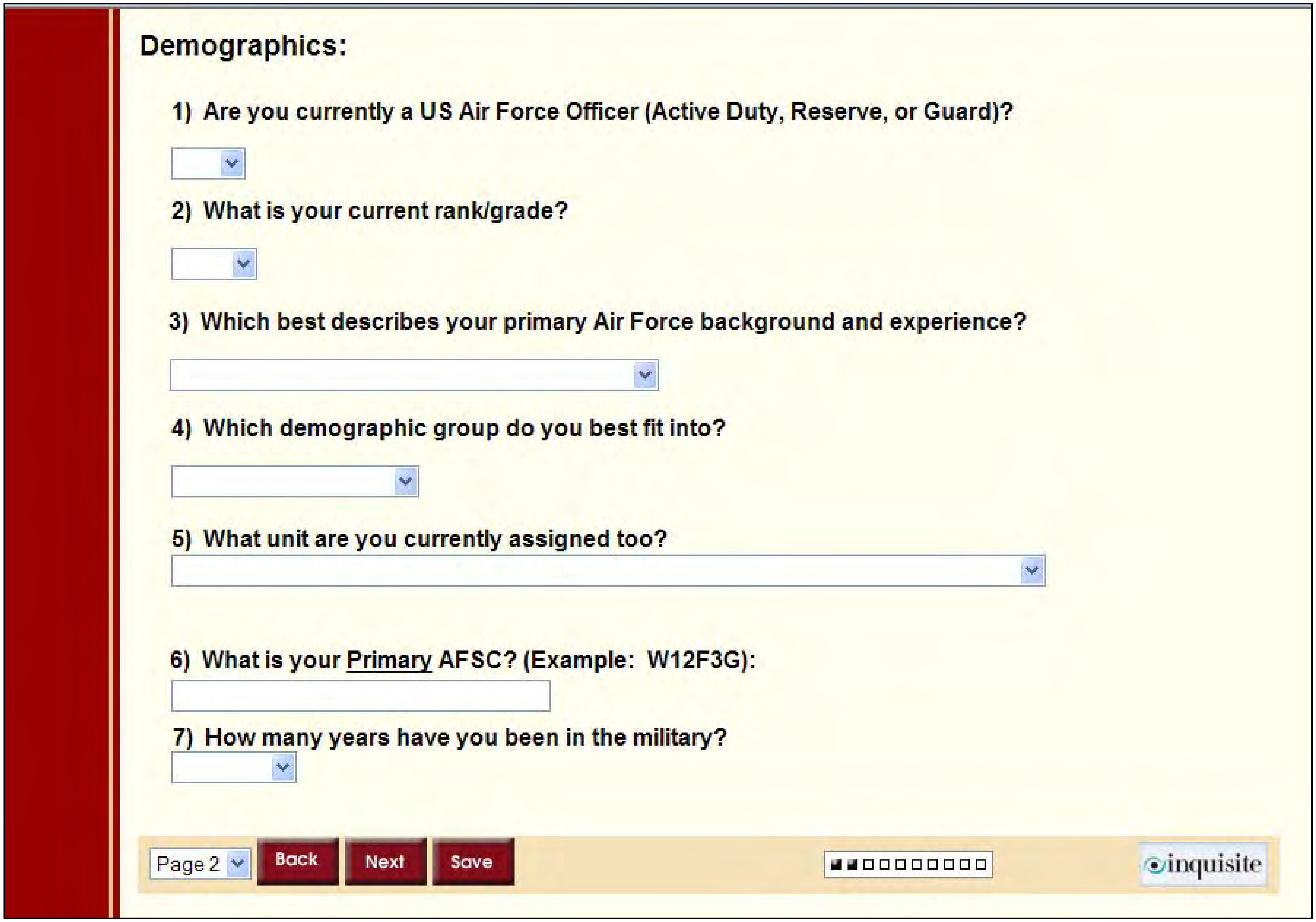
inquisite



Demographics:

1) Are you currently a US Air Force Officer (Active Duty, Reserve, or Guard)?

2) What is your current rank/grade?

3) Which best describes your primary Air Force background and experience?

4) Which demographic group do you best fit into?

5) What unit are you currently assigned too?

6) What is your Primary AFSC? (Example: W12F3G):

7) How many years have you been in the military?

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inquisite

8) Which best describes your level of experience with employing tactical airpower against ground targets?

- Multiple Major Combat Operations
- Major Combat Operation
- Limited Combat Operations
- Peacetime Training / Exercises
- Direct Supporting Role
- None

__MASINT__ *(Measurement and Signature Intelligence)*:
Technically derived intelligence data other than electro-optical imagery and SIGINT. The data result in intelligence that locates, identifies, or describes distinctive characteristics of targets. It employs a broad group of disciplines including nuclear, infrared, radiofrequency, acoustics, seismic, and materials sciences.

9) How familiar are you with Measurement and Signature Intelligence (MASINT)?

- Very Familiar, and expect to have access in combat if desired
- Very Familiar, but DO NOT expect to have access to it in combat
- Familiar, and expect to have access in combat if desired
- Familiar, but DO NOT expect to have access to it in combat
- Know that it exists, but would not know what to expect from it
- May have heard of it
- None

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inquisite

Traditional ISR: Intelligence, Surveillance, and Reconnaissance (ISR) collected from platforms designed with ISR collection as their primary purpose. These platforms include but are not limited to: Satellites, U-2, Global Hawk, Predator, Joint Stars, and Rivet Joint.

Non-Traditional ISR: ISR collected from platforms generally associated with other tasks, but possessing sensor capabilities that could complement the overall intelligence collection effort. Common example: Intelligence from Targeting Pods on fighter aircraft.

Shooter: Most tactical link in the decision making process for weapon employment. (Against GROUND TARGETS for this survey)

Please select your level of agreement with the following statements.	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree	No Basis for an Opinion
10) Dynamic Targeting (DT) / Time Sensitive Targeting (TST) / Time Critical Targeting (TCT) is a growing trend in air operations. (Considered DT, TST, and TCT as a single category)	○	○	○	○	○	○
11) Non-Traditional ISR was a planned capability envisioned when current sensors were designed for "Shooter" platforms.	○	○	○	○	○	○
12) New sensors developed for "Shooter" platforms should be designed to integrate better into the overall intelligence collection effort.	○	○	○	○	○	○
13) Non-Traditional ISR is a well integrated part of the intelligence collection effort.	○	○	○	○	○	○
14) Future adversaries are likely to target US communications / reach-back capabilities to reduce effectiveness of air operations.	○	○	○	○	○	○
15) Airborne manned traditional ISR assets are expected to remain Low Density / High Demand.	○	○	○	○	○	○
16) Airborne unmanned traditional ISR assets are expected to remain Low Density / High Demand.	○	○	○	○	○	○

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inquisite

***Shooter*:** Most tactical link in the decision making process for weapon employment. (Against GROUND TARGETS for this survey)

Please select your level of agreement with the following statements.	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree	No Basis for an Opinion
17) I am familiar with sensor technologies capable of highlighting scene changes from previous sensor passes / missions / etc.	○	○	○	○	○	○
18) Sensor technologies capable of displaying scene changes from previous sensor passes / missions / etc. would be useful to aircrew performing the "shooter" mission against ground targets.	○	○	○	○	○	○
19) I am familiar with sensor technologies capable of indicating the material composition of ground targets. (Ex. Type of Material / Paint / Chemical Emissions / etc.)	○	○	○	○	○	○
20) Sensor technologies capable of indicating the material composition of ground targets would be useful to aircrew performing the "shooter" mission against ground targets. (Ex. Type of Material / Paint / Chemical Emissions / etc.)	○	○	○	○	○	○
21) I am familiar with sensor technologies capable of building a 3-Dimensional representation of a scene / target.	○	○	○	○	○	○
22) Sensor technologies capable of building a 3-Dimensional representation of a scene / target would be useful in performing the "shooter" mission against ground targets.	○	○	○	○	○	○

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inquisite

Dynamic Environment:
An environment that has the potential to change significantly, independent of aircrew actions , between the collection of information used in mission planning and mission execution.

Non-Dynamic Environment:
While no environment is truly Non-Dynamic, some are relatively static for targeting purposes. For this survey, consider Non-Dynamic environments ones that do not significantly change between planning and execution.

Please select the the description that best completes the sentence:

23) In Dynamic Environments, aircrew prefer to make targeting decisions based upon information from:

- On-Board Sensors
- Off-Board Sensors
- No Basis for an Opinion

24) In Non-Dynamic Environments, aircrew prefer to make targeting decisions based upon information from:

- On-Board Sensors
- Off-Board Sensors
- No Basis for an Opinion

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inquisite

Please select your level of agreement with the following statements.	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree	No Basis for an Opinion
25) Future threats are likely to increase the use of deception techniques (camouflage / concealment / decoys) to disrupt ground targeting efforts.						
26) Sensors available today onboard "Shooter" platforms are sufficient for making friend / foe decisions in threat environments that include physical deception techniques (camouflage / concealment / decoys) of ground targets .						
27) Sensors expected in 2020 onboard "Shooter" platforms are sufficient for making friend / foe decisions in threat environments that include physical deception techniques (camouflage / concealment / decoys) of ground targets.						
28) Increasing sensor capabilities on-board "shooter" platforms is necessary in order to meet adversarial challenges of the future.						

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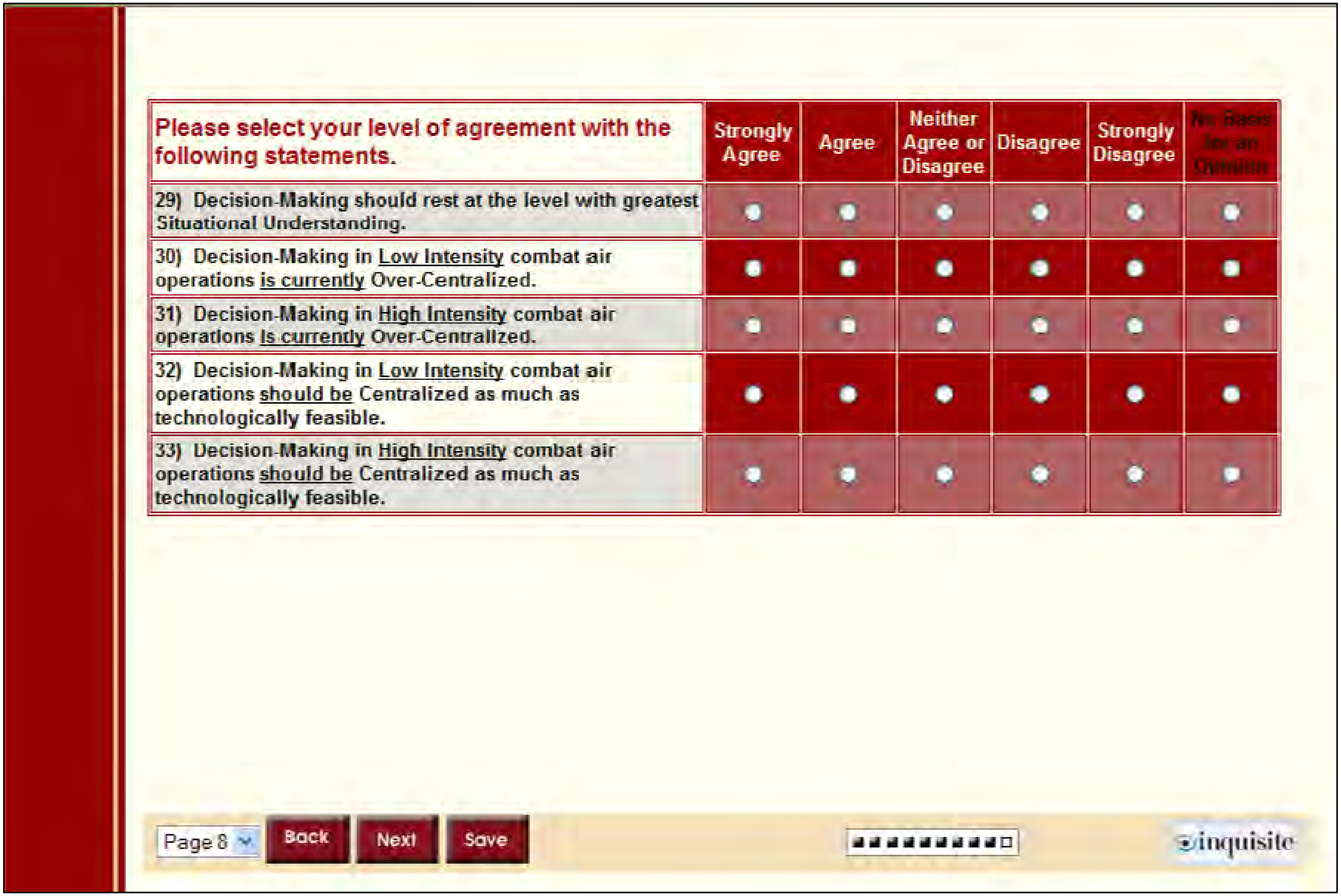

Please select your level of agreement with the following statements.	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree	No Basis for an Opinion
29) Decision-Making should rest at the level with greatest Situational Understanding.						
30) Decision-Making in Low Intensity combat air operations is currently Over-Centralized.						
31) Decision-Making in High Intensity combat air operations is currently Over-Centralized.						
32) Decision-Making in Low Intensity combat air operations should be Centralized as much as technologically feasible.						
33) Decision-Making in High Intensity combat air operations should be Centralized as much as technologically feasible.						

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inquisite

Please select your level of agreement with the following statements.	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree	No Basis for an Opinion
34) Sufficient efforts are made to make ISR products accessible to aircrews.						
35) Aircrews have sufficient security clearances to access ISR products.						
36) Secret Level networks, such as the Secret Internet Protocol Router Network (SIPRNet), are commonly accessible during combat mission planning.						
37) Top-Secret Level networks, such as the Joint Worldwide Intelligence Communication System (JWICS), are commonly accessible during combat mission planning.						

Comments (Unclassified):

Thank you for your time and assistance in completing this survey.

If you have questions or comments please contact:

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